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THE SOUTH AFRICAN DENTAL ASSOCIATION

The first black Africans to qualify in Dentistry in South Africa

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Our Front Cover for this Issue...

The theme for the Front Cover of the South African Dental Journal this year provides for some historical figures, some characters illuminating dental history and some important achievements in South African Dental history. The cover for November looks back to the first black Africans to qualify in Dentistry in South Africa.

The first black Africans to qualify in Dentistry in South Africa

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They are the first male and female black Africans to have qualified as dentists in South Africa. In itself that is a romantic record... but the excitement continued, for, later, Kenneth and Teresa married! A storybook theme!

Strict enforcement of the Population Registration Act of 1950 had for many years prevented the admission of black South Africans to the study of Dentistry. The registration of Kenneth as a Dental Student at Wits marked an opening of opportunities for black South Africans to enter the Dental Profession. By 1995, Wits had qualified 127 Black South African Dentists.

The Medical University of South Africa, MEDUNSA, was created in 1976 for the specific purpose of training black medical and dental practitioners. Dental Therapy students had been admitted in 1975 for training at the Madikoti Advanced College of Technology, based at Seshego.

The class completed study at Ga Rankuwa Hospital, and graduated in 1977. The first intake of Dental Therapy students at MEDUNSA was the next year, 1978, with the class graduating in 1981. The following year, 1982, marked the first intake of Dental students.

The Universities of Pretoria, of Stellenbosch, of Western Cape and of Natal have all followed suit opening the opportunities for all South Africans to enter the profession.

Between 2002 and 2015, the number of black professionals in Dentistry had increased by 129%, and in the same period the number of black dental specialists had increased by 400%. Impressive percentages, yes, but the actual numbers remained small. The population of South Africa was recorded in 2020 as 59,308,690... and the number of dentists was about 6,500, giving an approximate ratio of 0,92 dentists per 10,000 population. There remains the need to enhance that proportion.

Whilst looking at firsts in South African Dentistry, these colleagues are prominent... first black African Maxillo Facial and Oral Surgeon to qualify in South Africa: Dr Sydney Mogafe; First black African Orthodontist to qualify in South Africa; Dr Solly Nkhumulene: First black African to qualify in South Africa as a Periodontist: Dr Londiwe Shangase; First black African to qualify as a Prosthodontist: Dr Zola Ndimandi; First black African to qualify as a Community Dentist: Dr Tsepo Gugushe.

Achievement is never ordinary... but at least the opportunities are no longer extraordinary.

Sad note: Both Kenneth and Teresa have passed away.

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1. Bhyat A, Chikte U. The changing demographic profile of dentists and dental specialists in South Africa. International Journal of Dentistry. http//doc.org/10.1111/idj.12332/.
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3. Annual Report, 2018.2019. The Health Professions Council of South Africa.
4. The Dental Professionals Association. dpa.org.za/index.php/about-us.

The changing face of Dentistry in the COVID-19 pandemic

SADJ November 2020, Vol. 75 No. 10 p530

NH Wood
Managing Editor of the SADJ

The year is drawing to a close and with it we present to you the final issue of the South African Dental Journal for 2020. This year saw us face the terrible COVID-19 pandemic. As oral healthcare practitioners we have been challenged in many ways, and this placed many of us under extreme pressure. Unfortunately we are just starting to see a new rise, or second wave, in the numbers of positive COVID-19 cases being reported. This means that the pressure is not about to be released, and we continue to navigate these uncharted waters into 2021.

In February we were uncertain about the impact of COVID-19 on our healthcare systems and our country, however we have now seen the course and the progression of this disease in many countries, and we know the reach it has and the devastating infection it causes. In light of this I am reminding you of the required infection control processes and procedures that need to be in place to protect yourself, co-workers and your patients.

The same is true for the various dental schools throughout the country: The staff and students within these schools have faced unprecedented challenges to break through the COVID-19 obstruction of academic activity, to be able to continue with the high-quality training of students in different disciplines of oral healthcare. All teaching has moved to online platforms and clinical competency training in contact sessions are strictly controlled and monitored according to policies and procedures specifically developed for the COVID-19 pandemic. This colossal effort must be recognised because many have made, and are still making, personal sacrifices in an immense effort to see to it that a continuous stream of oral healthcare graduates is maintained.

Neil H Wood: Managing editor. Email: neil.wood@smu.ac.za

However, I must urge these institutions of higher learning to look after their staff and to take care of the well-being of these individuals, both physically and mentally. It is because of the enormous efforts and the unrelenting pressure to produce deliverables and outcomes based on pre-COVID-19 conventions and designs, that levels of exhaustion may be precariously high; and our clinicians and students must be protected against burnout. Protocols and measures must be put in place by these institutions to guard against these unintended deleterious outcomes.

There is no doubt in my mind that COVID-19 has radically changed the way clinical dentistry, academic dentistry and clinical teaching and training is conducted, and that there will be no return to the ways of the past.

The South African Dental Journal's new online platform is now fully operational and functioning. Please take a moment to visit the new online platform on which the South African Dental Journal is hosted at https://journals.assaf.org.za/index.php/sadj/index and register as a reviewer or author. I would also appreciate any feedback that you as a reader, author or reviewer may have on this new platform, as we are always looking for ways to improve on the SADJ delivery. This issue of the SADJ contains another healthy mix of content for our readers along with provision for acquiring CPD points.

Our regular contributors once more support us with interesting material that includes the radiology case prepared by Prof C Nortjé, and some views on recently published material compiled by Prof Yengopal.

A sincere word of thanks to all our authors, reviewers and other contributors for the participation in making the 2020 edition of the SADJ a success. We truly have a journal that belongs to our dental community. I would like to express my gratitude for the hard work and dedication put into the 2020 edition of the SADJ by all the members in the team, Dr Nthabiseng Metsing, Mr Dumi Ngoepe, Mrs Ann Bayman, as well as our colleagues at the production office Ms Reine Combrinck and Mr Rene Smulders. Thanks also to Prof Bill Evans for his contributions toward the cover-page and his gracious guidance. The year saw many changes and improvements to our journal, and may it long continue.

From the Editorial office we would like to wish our readers and our members a safe and peaceful festive season. We look forward to the new year to achieve and celebrate new success and development with you.

SADA communique to members
- Licence and quality control tests for dental diagnostic X-ray imaging systems

SADJ November 2020, Vol. 75 No. 10 p531 - p533

SADA Head Office

Members have been receiving notification from Inspection Bodies about their X-ray equipment being due for inspection.

On enquiry, it has been discovered that, in some instances, this notice was based on erroneous data that Inspection bodies may have received from the Radiation Control, who had not correctly updated their records, due to "a lack of manpower".

SADA strongly advises members who receive this notification to check their documentation before booking said inspections and, if the notification is incorrect, to request their usual inspection body to correct their records.

SADA has serious concerns about the current legal framework and enforcement of the Act governing X-ray equipment. It questions the Code of Practice and more particularly, the legal standing of inspection bodies, licensing delays and the entire legislative framework. To this end, SADA has made an extensive written submission to the Minister of Health raising our concerns. In the meantime, as the legislative framework applies to practitioner, in its flawed framework, we provide members useful information for the benefit of members around the whole issue of licensing and testing of X-ray equipment so that members are properly informed when receiving notices of inspections or having to licence their new or used X-ray equipment.

INTRODUCTION

The South African Health Products Authority (SAHPRA) is the regulatory authority of South Africa responsible for the regulation of health products intended for human and animal use; amongst others, radiation emitting devices and radioactive nuclides.

The legislative mandates of SAHPRA are derived from the Constitution; the National Health Act, 2003 (Act No. 61 of 2003); the Medicines and Related Substances Act, 1965 (Act No. 101 of 1965), as amended (hereinafter referred to as "the Medicines Act"); and other relevant legislation, regulations and policies.

Further, SAHPRA's mandate has expanded to include the regulation and control of radiation emitting devices and radioactive nuclides under the Medicines Act and the Hazardous Substances Act, 1973 (Act No. 15 of 1973). The Hazardous Substances Act does not

allow any person to use radiation equipment unless he/she holds a licence under the Act for that purpose.

Licence

The Regulations require that a joint product and premises licence be obtained for X-ray equipment before it may be installed and commissioned.

(a). Licences are not transferable and are issued: To a specific person or institution; For specific equipment and its application, and

(b). For a specific premise.

It is the responsibility of the prospective user of an x-ray unit to be in possession of a licence from the regulator prior to installation of the unit. Practitioners may be assisted by the supplier of the equipment in this process.

(Form RC001) (01/2016) application for a licence in terms of the hazardous substances act, 1973 (Act 15 of 1973) to use an X-ray device)
https://www.sahpra.org.za/radiation-control/

Pre-owned units

The prospective user must ensure that acceptance tests are performed. Granting of a licence to use a unit is subject to submission of the results of the tests to the regulator.

When an existing licenced unit is moved to a new premise (building) or room, prior to use, acceptance tests must be performed on the unit and the results submitted to the regulator.

(**Form RC001**) (01/2016) application for a licence in terms of the hazardous substances act, 1973 (act 15 of 1973) to use an x-ray device).
https://www.sahpra.org.za/radiation-control/

New/modified premises

The licence holder must apply for and obtain permission prior to:

(a). Modification of any licensed premises or layout of equipment on such premises, and/or

(b). Change of licensed premises (building) or equipment moved to other rooms within the same building.

(Form RC002) application in terms of article 4 of the hazardous substances act, 1973 (act 15 of 1973) - disposal of a licensed electronic product and/or new/ modified premises:
https://www.sahpra.org.za/radiation-control/

Acceptance and routine quality control tests

An Inspection Body (IB) approved by the Department of Health (DoH)/ SANAS must be used to perform all the acceptance tests. The present accredited Inspection Bodies on the SAHPRA website (as at 7 March 2019) are shown in Table 1.

Acceptance tests

Acceptance tests are the initial tests performed directly after installation and before the equipment is being put into clinical service.

Acceptance tests have three purposes, namely:

(a). To ensure that the unit meets stated specifications.

(b). To establish baseline parameters for the future quality control program.

(c). To familiarize the customer with operation of the unit.

New units

When a new unit is installed, acceptance tests must be performed by the supplier of the x-ray unit and the results recorded on the prescribed form and filed in the Individual Equipment Record (IER) of the unit. The IER is for example, a ring binder containing all the information as prescribed in Table 1 below for each piece of equipment.

Pre-owned units

The prospective user must ensure that acceptance tests are performed. Granting of a licence to use a unit is subject to submission of the results of the tests to Radiation Control.

When an existing licenced unit is moved to a new premise (building) or room, prior to use, acceptance tests must be performed on the unit and the results submitted to Radiation Control.

Table 1. Currently accredited Inspection Bodies on the SAHPRA website (as at 7 March 2019).

Company	Location	Contact	Tel	Email
Africa X-ray Industrial & Medical	Midrand	Mr Peter Wolff	011 314 0140 083 380 7359	peterw@axim.co.za
Gendent	Durban	Mr Graham Wollentine	031 202 8690 083 229 6380	graham@gendentsa.co.za
Millner's Dental Suppliers	Cape Town, Johannesburg	Mrs Erika Vorster	086 010 0200 011 549 9621	erika@wright-millners.co.za
Sirona Dental Systems South Africa (Pty) Ltd	Woodmead, Johannesburg	Bernice Muller runs the department NO TESTING TECHNICIAN AT PRESENT TIME	010 001 2827 082 215 6724	benjamina.muller@dentsplysirona.com

Table 2. Quality control tests are performed at the following prescribed frequencies.

Acceptance and routine tests listed in this section must be performed by an approved Inspection Body	
Extra-oral X-ray tubes with intra-oral image receptors, panoramic radiography and cephalometric radiography	On acceptance and 3 years
Dental cone beam CT	On acceptance and 12 monthly
Dental cone beam CT: DAP	On acceptance and 24 monthly
Film Viewing (Viewing boxes used for reporting/interpretation of medical images)	On acceptance and 3 years
Reporting monitors	On acceptance & 3 years
CR reader	On acceptance & 3 years
DDR system	On acceptance & 3 years
For the full document (Please see Code: Diagnostic QC Dental (March 2017) Version 10 link 2 below).	

Quality Control tests (QC)

Some routine tests are required to be carried out by the practitioner as licence holder and others by the appointed Inspection Body (Please see II Table 2 (page 9) in CODE: DIAGNOSTIC QC DENTAL (March 2017) Version 10 link 2 below). All the quality control tests are performed at the prescribed frequencies as specified in Table 2, the frequency may also be influenced by the age, stability, make, model, etc., of the equipment.

Useful contacts

Group III hazardous substances.

Installation and use of new Group III equipment:
Dental X-rays: **rcdent.xrays@sahpra.org.za**

Installation and use of pre-owned Group III equipment:
Gauteng, North West, Limpopo and Mpumalanga:
cyril.mathiba@sahpra.org.za

Western Cape and Northern Cape:
debbie.coetzee@sahpra.org.za

Kwazulu-Natal, Free State and Eastern Cape:
mala.bickhoo@sahpra.org.za

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2. https://www.sahpra.org.za/wp-content/uploads/2020/01/DIAGNOSTIC-QC-Dental-March-2017-Version-10-2.pdf.
3. SAHPRA website: https://www.sahpra.org.za/radiation-control/.

Do the CPD questionnaire on page 591

The Continuous Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.

Online CPD in 6 Easy Steps

1. Go to the SADA website www.sada.co.za.
2. Log into the 'member only' section with your unique SADA username and password.
3. Select the CPD navigation tab.
4. Select the questionnaire that you wish to complete.
5. Enter your multiple choice answers. Please note that you have two attempts to obtain at least 70%.
6. View and print your CPD certificate.

http://dx.doi.org/10.17159/2519-0105/2020/v75no10a1

A base-line study of the wear of burs used for chairside milling of ceramic crowns of different hardness
- Effect on internal fit and surface roughness

SADJ November 2020, Vol. 75 No. 10 p534 - p540

AA Ahmed[1], CP Owen[2]

ABSTRACT

Introduction
Wear of milling burs may affect the internal fit and surface roughness of the milled crown. Aim: To assess the wear of diamond and tungsten carbide (TC) burs from milling ceramic materials and the effect on internal fit and surface roughness.

Methods
Thirty crowns of each of the two materials were milled from the same standard preparation. Diamond burs were used for a feldspathic ceramic and TC burs for zirconia. Before and after the 10th, 20th and 30th milling, diamond particle loss was counted and cutting blade changes of the TC burs measured. Internal fit was measured using a silicone replica technique and surface roughness by 3D laser microscope.

Results
An average 26% loss of diamond particles occurred after 30 crowns, resulting in a 6% decrease in internal luting space and a 21% decrease in surface roughness. Wear of the TC burs resulted in a 13% decrease in the luting space, and a 16% increase in surface roughness.

Conclusion
The wear of milling burs reduces the luting space, and the milling parameters must be adjusted to compensate for this. Surface roughness is affected by bur type: with diamond burs it decreased, and increased with TC burs.

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Author contributions:
1. **Ayman A Ahmed:** Methodology, validation, investigation, writing, review - 50%
2. **C Peter Owen:** Conceptualization, methodology, validation, writing - original draft; review and editing; supervision; project administration - 50%

Keywords
CAD/CAM milling burs, internal fit, surface roughness, ceramics.

INTRODUCTION

In recent years, many dental Computer Aided Design and Computer Aided Manufacture (CAD/CAM) systems have been developed and introduced to the market both for chairside milling as well as laboratory fabrication, and restorations made this way have become more affordable and increasingly accurate.[1]

Milling systems, however, still have some constraints, related to movements of the axes, necessitating that the scanner is able to see all parts of the preparation without undercuts, as well as the size of the burs, which in turn influences the preparation form. The diameter of the smallest bur is 1 mm in most systems, so structures smaller than 1 mm cannot be milled precisely.[2]

A number of researchers have investigated the effect on the accuracy of the milled crowns and the loss of diamond particles from the bur after repeated machining up to 30 and sometimes 50 crowns using one diamond bur.[3,4] Yara and colleagues (2005)[3] found that a diamond bur could be used to fabricate up to 21 crowns when using two different milling systems using feldspathic ceramics of different Vickers hardness. Furthermore, they showed that the crowns' average surface roughness ranged from 1.1 to 2.1µm for the one system and from 0.8 to 1.6µm for the other. There were significant diamond losses of 34% and 8% respectively. They concluded that the Vickers Hardness of the ceramic blocks used influenced the diamond particle loss as well as the surface roughness.[3]

Tomita et al (2005)[4] found that one diamond bur could be used to fabricate up to 51 feldspathic crowns using their milling system but that from the 41st to 51st crown there was a tendency to mill with a larger inner surface gap and a slightly smaller outer surface.

They also found tiny chip marks at the cervical contour from the 21st to 51st crowns. SEM observation showed

that after 11 to 21 times of machining the diamond abrasive particles were gradually lost as the number of machining times increased.[4] Other studies reported an increase in surface roughness when milling Vita Mark II ceramic blocks and observed, but did not quantify, bur wear.[5,6] A study to determine whether machining variability might impact on the strength of chairside ceramics, found that surface roughness and bi-axial flexure strength were influenced by the bur sets used, i.e. the machining tool variability.[7]

These studies have shown that diamond burs used for chairside milling of restorations are subject to wear in proportion to the hardness of the material being milled, and the number of times the bur was used. This in turn has an influence the surface roughness of the restoration. It is therefore imperative to know the precise relationship between the state of wear of the bur and the effect on milling accuracy and surface roughness.

In general, wear has been measured by particle loss in diamond burs by observations on only one part of the bur.[3,4] There have been few reports on the wear of tungsten carbide burs, and most have reported on dulling and rupture of the blade edges of dental handpiece burs when cutting ceramics,[8] or observations of chipping on tungsten-carbide burs used for milling titanium crowns.[9]

The creation of a luting space for full crowns was originally advised to create space for the luting agent. With CAD/CAM systems the milling constraints have given rise to recommendations for the creation of a luting space of up to 100 µm. A variety of methods have been used to measure this space, such as the use of micro-CT which unfortunately requires expensive equipment, as well as the more cost effective use of a silicone replica as described by Nakamura et al (2003).[10] These provide a measure of the total internal fit of the preparation.

The aim of this study was to assess the wear of diamond and tungsten carbide milling burs after milling up to 30 full crowns from two different ceramic materials of different hardness, and the effect of this wear if any, on the internal fit and surface roughness.

METHODS

A typodont tooth (tooth 36) was prepared to receive an all-ceramic crown restoration. The preparation had a circumferential shoulder margin, an axial reduction of 1.5 mm, a 1.5 mm occlusal reduction, rounded internal angles, and 12° total occlusal convergence angle. The crown was scanned (CEREC Omnicam, Dentsply/Sirona, Germany) and printed in Cobalt-Chromium.

For the crowns, the milling parameters were set to produce an internal gap of 200 µm, in order to ensure that this space did not unduly influence subsequent measures of fit.[11] The materials used were Sirona blocs C (Dentsply Sirona, Germany) and Zirconium oxide (inCoris TZI puck, Dentsply Sirona, Germany). The MC X5 milling machine (Dentsply/Sirona, Germany) was used to mill all crowns. Diamond burs (set of 1.2, 1.4 and 2.2 mm sizes, Dentsply/Sirona, Germany) were used to mill the Sirona blocs C. Tungsten Carbide burs (set of 0.5, 1.0 and 2.5 mm sizes, Dentsply Sirona, Germany) were used to mill the inCoris TZI puck.

Prior to milling, and after the 10th, 20th and 30th milled crowns the milling process was paused, and the burs were scanned by Scanning Electron Microscope (SEM) (Carl Zeiss Sigma Filled Admission Zeiss, Germany), to count the particles lost after a method modified from Yara et al (2005).[3] They were then re-installed to continue milling the crowns. The Zirconia burs were similarly scanned in order to determine any edge wear.

For the diamond burs, the bur shank was marked into four quadrants around its circumference to ensure that measurements were made in the same quadrant each time. The burs were scanned with magnifications of 100x, 200x and 500x. The SEM images of the burs were imported into a computer graphics programme (CorelDraw, Corel, Canada). A frame of 1 mm high and 1 mm wide, was prepared in the computer with a 10 x 10 grid. The top margin was adjusted to be 0.5 mm from the top of the bur and centred from the sidewalls of the bur. This frame was used to count the diamond particles within it (Fig. 1). One observer was used but we did not test for intra-rater reliability which is a possible limitation, but the concern was with the trend of wear. Fig. 2 shows the tip of the bur under magnification 500 times before, and at the 10th, 20th and 30th milled crowns.

For the tungsten carbide burs, as previous studies have reported only chipping of the burs after milling, this study set out to quantify the wear. The burs were scanned before use, and the diameter (Y) and width (X) of the blades were measured (Fig. 3).

It was found that the SEM scan of the burs after milling did not provide accurate quantification measurements, due to the different scales and angles when scanned, and therefore a statistical proportional method was adopted to calculate any differences due to wear.

With X1 being the width after milling, the blade wear is X – X1. With Y1 being the bur diameter after milling, proportionally, X1 = X (Y1/Y) as X/Y is proportional to X1/Y1.

The 1st, 10th, 20th and 30th crowns of both materials were filled with light-body polyvinyl siloxane impression material (3M ESPE Express. 3M, United States) and placed on the metal tooth die under a constant load of 3 kg weight, placed on the flat occlusal surface of the crown for 10 minutes. After the silicone impression material had polymerised, the excess material was removed with a scalpel blade. The material from the internal gap was taken out as one piece and weighed to calculate the overall internal fit according to the formula:[10]

$$\text{Thickness (internal gap)} = \frac{(weight)}{((surface\ area \times density))}$$

Where the surface area was 183.8 mm^2 (calculated using FEA software) and the density was 1.29 g/ml (obtained from the manufacturer).

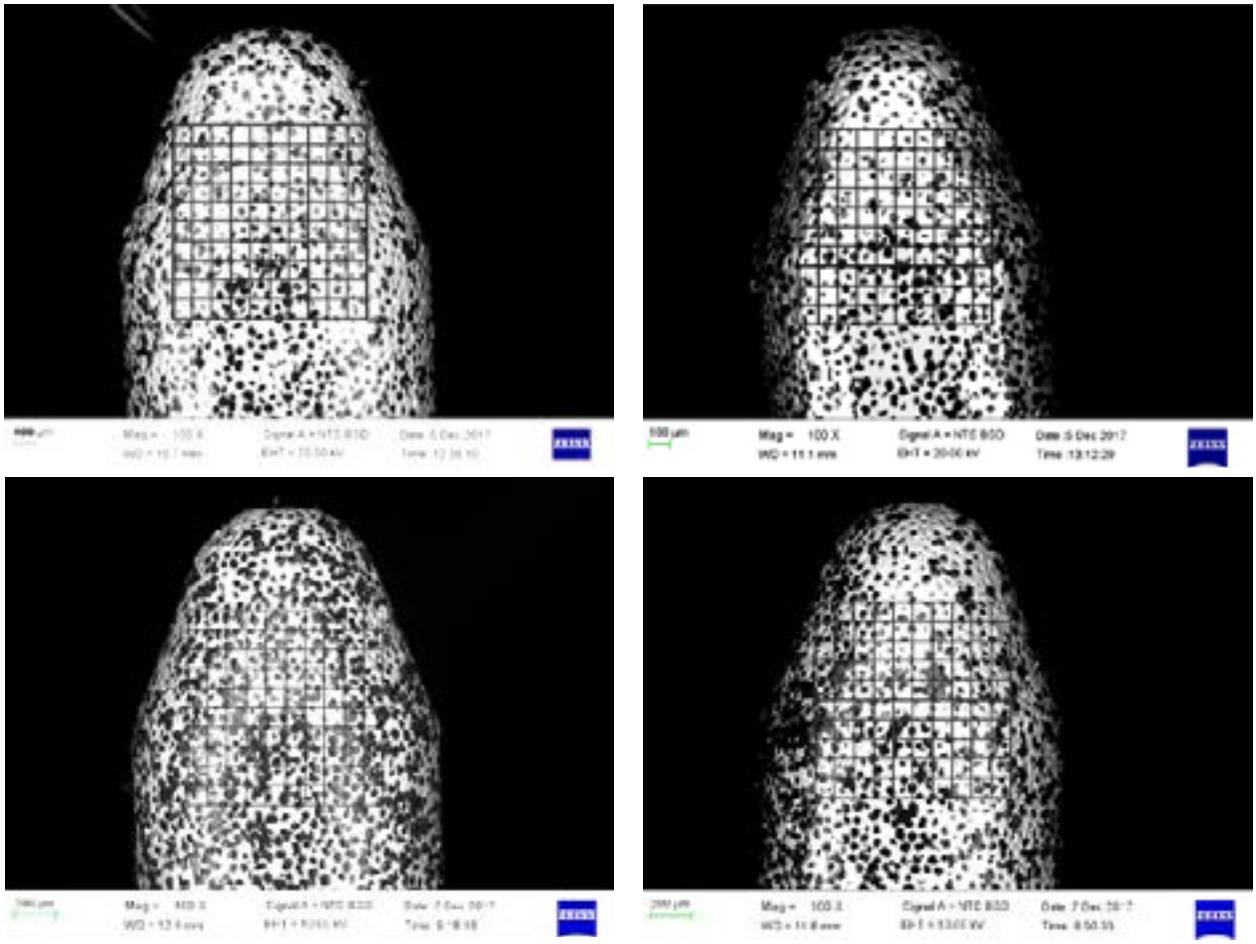


Figure 1. The four quadrants of the Diamond bur, size 1.2 mm before milling.

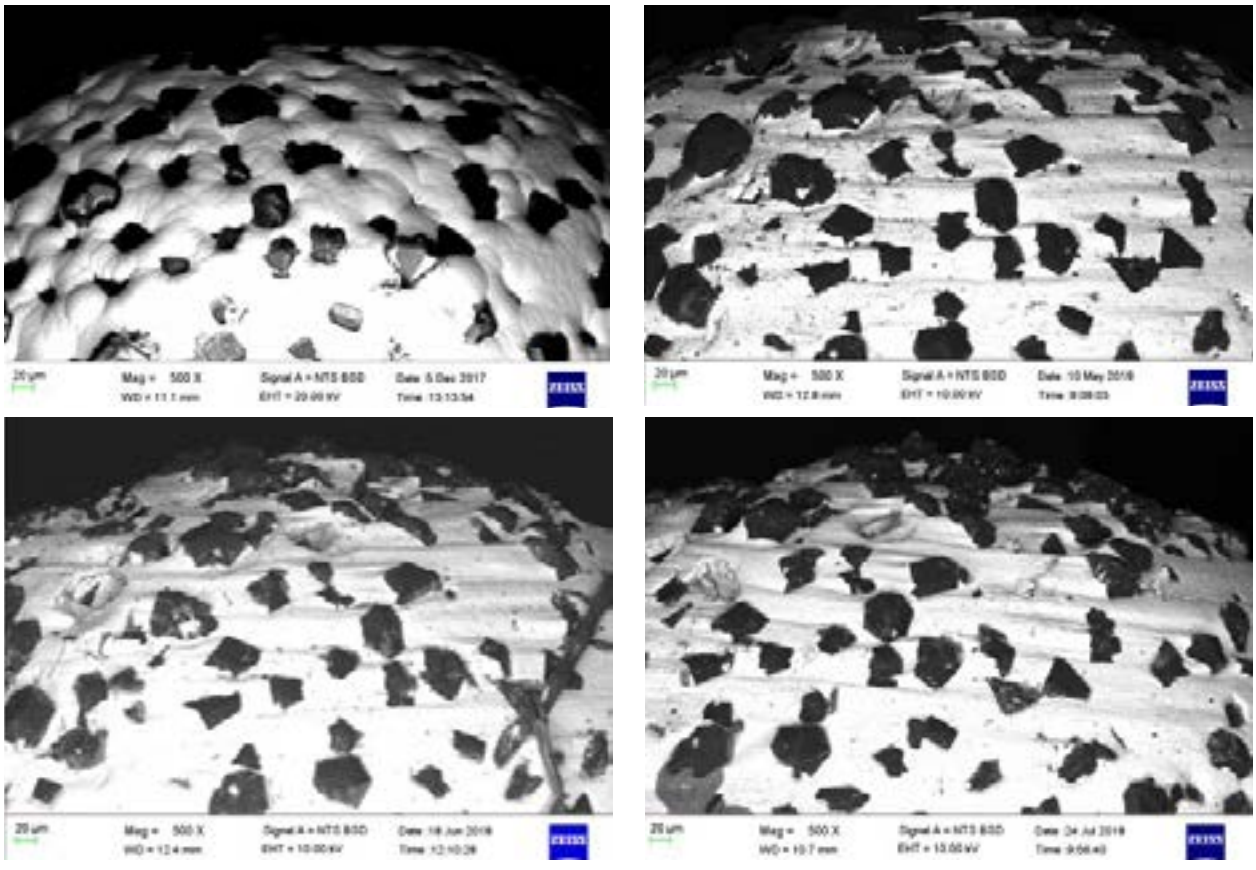


Figure 2. The Diamond bur, size 1.2 mm magnification X500 before milling (**top left**), after milling the 10th crown (**top right**), after milling the 20th crown (**bottom left**), and after milling the 30th crown (**bottom right**).

The 1st, 10th, 20th and 30th crowns of both materials were scanned with a 3D Measuring Laser Microscope (Olympus LEXT OLS5000, Olympus Corporation, Japan) to measure the surface roughness. On the software (OLS50-BSW, Olympus Corporation, Japan) a frame size 12µm x 12µm was placed on the occlusal surface of the crown to give the average surface roughness (Fig. 4).

The analysis parameter used was the arithmetic mean height (Sa). It is equivalent to the arithmetic mean of the measured region on the three-dimensional display diagram when valleys have been changed to peaks by conversion to absolute values (as per Olympus resource at https://www.olympus-ims.com/en/knowledge/metrology/roughness/3d_parameter/).

Data analysis

Continuous variables were summarised by the mean, standard deviation, median and interquartile range. The effect of material and number of crowns milled on the internal fit (IF) and surface roughness (SR) outcomes was determined by a two-way Analysis of Variance (ANOVA) with the outcome as the dependent variable,

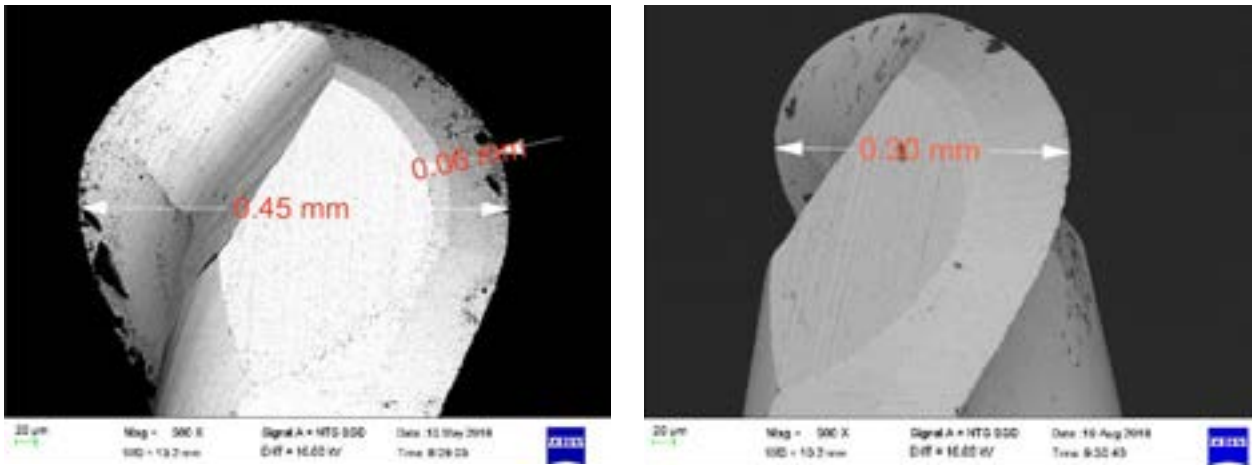
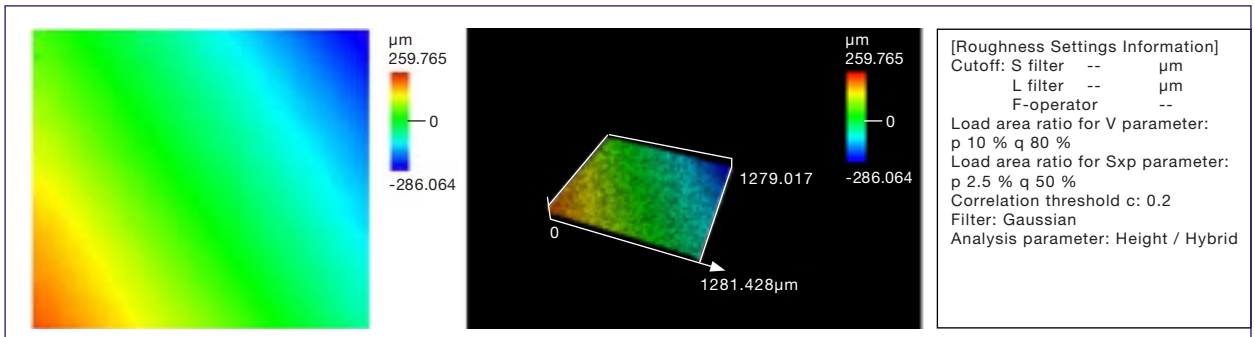


Figure 3. Bur size 0.5 for Zirconia. (**Left**) before milling, (**right**) after milling of the 30th crown, magnification 500x.



No.	Result	Sq[µm]	Ssk	Sku	Sp[µm]	Sv[µm]	Sz[µm]	Sa[µm]	Sdq	Sdr[%]	FOperator	S-filter[µn	L-filter[µn
1	-	3.999	-0.833	8.586	33.092	56.433	89.525	3.033	2.211	117.753	--	-	-

Figure 4. Sirona blocs C surface roughness for Crown number 1.

Table 1. Wear of Diamond Particles in the area measured.

Milling time	Bur size	Side 1	Side 2	Side 3	Side 4	Average	% Loss
Before 1	1.2	280	284	300	288	1152	-
	1.4	251	249	223	249	972	-
	2.2	126	122	131	145	524	-
					Total average particle wear	2648	-
After 10	1.2	246	229	253	236	964	16
	1.4	229	234	230	230	923	5
	2.2	86	102	103	101	392	25
					Total average particle wear/% loss	2279	14
After 20	1.2	262	195	236	198	891	23
	1.4	213	217	210	209	849	13
	2.2	75	98	109	97	379	28
					Total average particle wear/% loss	2119	20
After 30	1.2	218	190	251	221	880	24
	1.4	226	190	156	195	767	21
	2.2	66	105	110	43	324	38
					Total average particle wear/% loss	1971	26

and material and number of crowns milled as the independent variables.

The interaction between material and number of crowns milled could not be assessed, as there were insufficient degrees of freedom for such an analysis. The relationship between wear and number of crowns milled for each material was explored descriptively, as were the relationships between IF, SR and wear for each material. Data analysis was carried out using SAS version 9.4 for Windows. The 5% significance level was used.

RESULTS

Table 1 shows the wear of diamond particles. This table gives the measurement values of three bur sizes making use of the four sides of the bur. It can be seen that the total particle loss after the 10th milling time was an average of 369 particles, while after 30th milling time the particle loss was an average of 677 particles, an average loss of 26%.

Table 2 shows the results of the milling of the Zirconium Oxide using different bur sizes. It shows the average wear of the burs of different sizes in mm. The minimum value of wear occurred with the 2.5mm bur size (0.03mm) and the higher value occurred with the 1.00mm bur size (0.12mm).

Table 3 and Fig. 5 show the milling times for Sirona blocs C together with the average wear (loss) of bur particles, the internal fit and the surface roughness, and Table 4 and Fig. 6 shows the similar parameters for the Zirconia. There were no statistically significant differences between the materials (p = 0.32) in terms of the surface roughness or for the internal fit (p=0.12).

Figure 5. Sirona Blocs C average wear (Particles, green), internal fit (IF, blue), and surface roughness (Sa, orange).

Figure 6. Zirconia burs average percentage change (green), internal fit (IF, blue), and surface roughness (Sa, orange).

For the Sirona blocs and diamond burs, there was an overall 6% reduction in the internal fit and a 21% reduction in surface roughness. For the Zirconia, there was an overall 13% reduction in the internal fit and a 16% increase in surface roughness.

DISCUSSION

The results revealed a clear relationship between the wear of the burs and the number of crowns milled. Wear was assessed in the diamond burs by the loss of particles, and the results were similar to the findings of other studies.[3,4]

Studies on the wear of non-diamond burs have been limited to counts of chips off the cutting blades. We believe that the method of assessing wear whereby SEM photomicrographs could be directly measured and a factor derived to represent the wear is a more accurate measure of wear for these burs.. As with the diamond burs, there was clearly an increase in wear with the number of crowns milled.

There were no statistically significant differences between the two materials tested. This may be explained by the fact that both materials used, had relatively low Vickers Hardness numbers. This has been related to bur wear in previous studies.[3]

In this study, there was no clear trend in the percentage of particles lost relative to the diamond bur sizes, with the 1.4mm diameter bur displaying the least percentage loss of particles (21%) followed by the 1.2mm bur (24%) and the 2.2 mm bur (38%).

For the diamond burs, with increasing numbers of crowns, there was a concomitant increase in bur wear, as well as a decrease in internal fit (6% after 30 crowns), and a decrease in surface roughness (21% after 30 crowns).

Table 2. Wear of tungsten carbide burs.

Milling time	Bur size	Average wear (mm)	% Change
After 10	0.5	0.0093	1.86
	1.0	0.0017	0.17
	2.5	0.00324	0.13
Total average wear/% change		**0.01424**	**0.72**
After 20	0.5	0.0173	3.46
	1.0	0.0034	0.34
	2.5	0.00972	0.39
Total average wear/% change		**0.03042**	**1.4**
After 30	0.5	0.02	4.00
	1.0	0.0068	0.68
	2.5	0.02916	1.17
Total average wear/% change		**0.05596**	**1.95**

Table 3. Sirona Blocs C average wear, internal fit, and surface roughness.

Crown milling number	Average number of diamond bur particles in 1 mm² frame	Internal fit silicone	Crown average surface roughness Sa (µm)
1	2648	0.192	3.270
10	2279	0.189	3.033
20	2119	0.186	3.061
30	1971	0.181	2.591

Table 4. Zirconium Oxide average percentage change of the burs, the internal fit and the surface roughness.

Crown milling number	Average % change	Internal fit silicone	Crown average surface roughness Sa (µm)
1	-	0.209	2.479
10	0.72	0.192	2.928
20	1.40	0.190	2.220
30	1.95	0.181	2.953

These are logical trends, and point to the fact that when milling with diamond burs, to maintain the internal luting space, the parameters for milling must be adjusted to compensate for bur wear. If this is not done, then the internal milled luting space may be inadequate and may result in incomplete seating of the crown. This may explain any change in occlusion post-cementation, which should not occur if the luting space is adequate.

For the tungsten-carbide burs, similar trends were observed for bur wear and internal fit (13% after 30 crowns), but there was an overall increase in surface roughness (16% after 30 crowns). This may be explained by the increased chipping of the cutting edge which will increase the roughness.

Limitations

This study only investigated the internal fit and surface roughness and not the marginal gap; only two ceramics were used, and feldspathic porcelain is sintered, and zirconia is partially sintered. This was, though, a baseline study and further studies are recommended using different ceramics and burs, so that recommendations can be made as to when to not only change the burs, but also to adjust the milling parameters and to determine for each bur and material combination, the number of crowns at which clinically unacceptable results would be obtained.

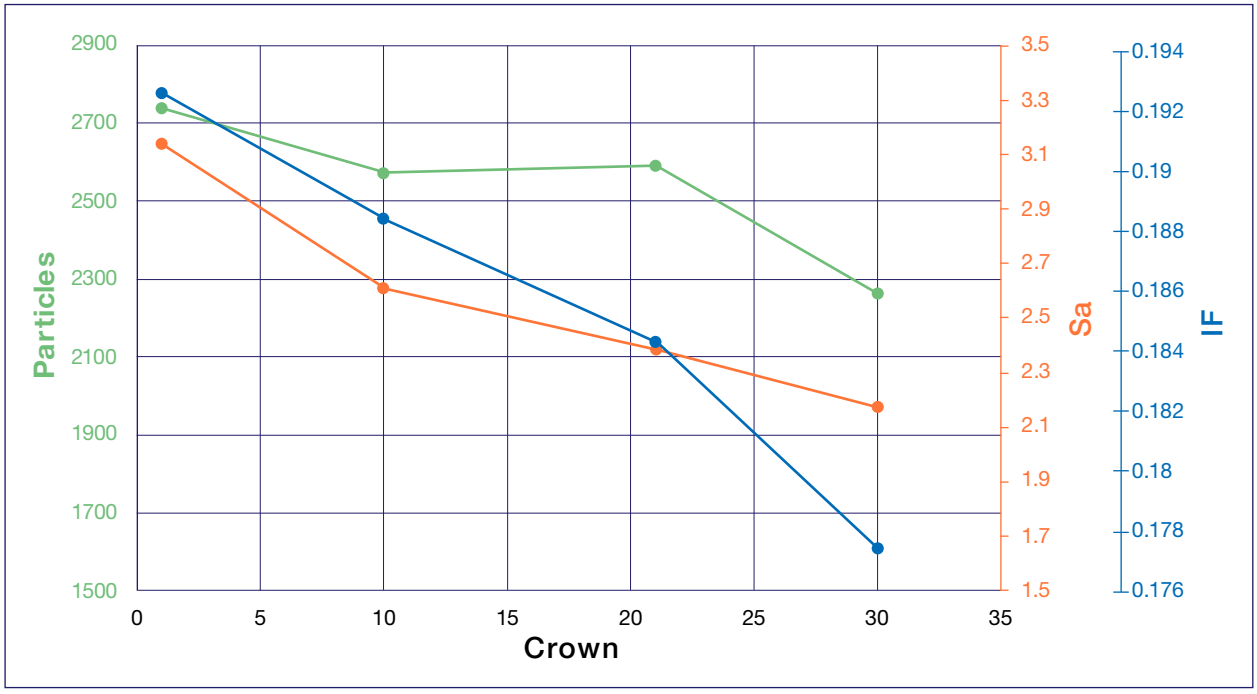


Figure 5. Sirona Blocs C average wear (**Particles, green**), internal fit (**IF, blue**), and surface roughness (**Sa, orange**).

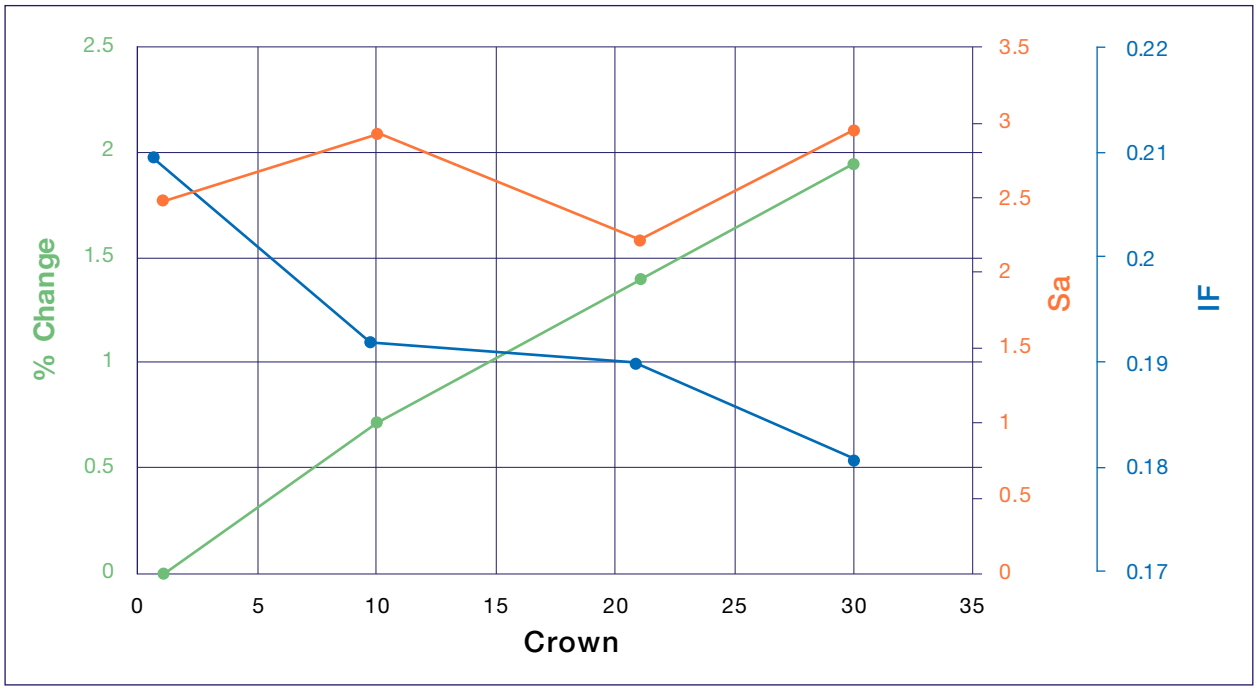


Figure 6. Zirconia burs average percentage change (**green**), internal fit (**IF, blue**), and surface roughness (**Sa, orange**).

CONCLUSION

This would appear to be the first study to measure the wear of diamond burs in four quadrants and compare this with the internal fit and surface roughness, using two different materials. It is also the first study to measure the cutting blades of tungsten carbide burs, and may be used as a baseline for other future studies to compare against.

The results, showed trends that were expected and confirmed that with increasing bur wear, either as particle loss in diamond burs, or reduction in cutting blade size in tungsten-carbide burs, there was a concomitant decrease in the internal fit of 6% and 13% respectively after 30 crowns. It is important, therefore, to compensate for this by adjusting the milling parameters.

The nature of the wear in the tungsten carbide burs was such that the cutting blades became rough, and this resulted in an increase in surface roughness (16%) of the milled crown. In contrast, the nature of the wear in diamond burs is a reduction of particle numbers, such that the bur becomes smoother, and this was reflected in the decrease in surface roughness (6%) with the number of crowns milled.

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Epidemiological profile of patients utilizing dental public health services in the eThekwini and uMgungundlovu districts of KwaZulu-Natal province, South Africa

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ABSTRACT

Introduction

Oral conditions such as dental caries, periodontal diseases, tooth loss and trauma affect millions of people globally. These conditions can be prevented when detected early, thereby avoiding adverse outcomes.

The prevalence of oral conditions has been reported in most provinces. However, there is a paucity of data in KwaZulu-Natal.

Aim and objective

This study aimed to determine the prevalence of oral conditions at public health facilities in two health districts in KwaZulu-Natal, South Africa.

Materials and methods

A cross-sectional analytical study design was used to determine the nature of oral conditions treated in dental facilities in the eThekwini and uMgungundlovu districts, in KwaZulu-Natal. The study was conducted over a 5-month period (November 2018 - April 2019).

After clinicians examined the patients they entered the data in the patients clinical records and selected information (routine medical history questions as well as 16 possible diagnosis codes) were entered into a data extraction template. The data were analyzed using statistical software SPSS.

Results

Dental caries was the most prevalent oral condition at 66.4% followed by periodontal disease at 11.7%, trauma at 7.3% and lastly tooth loss at 5.9%.

Conclusion

These findings contribute to knowledge on the prevalence of these oral conditions found in the province.

Keywords

Dental caries, periodontal diseases, trauma, tooth loss, prevalence.

ACRONYM

ANUG:	Acute Necrotizing Ulcerative Gingivitis
BREC:	Biomedical Research and Ethics Committee of the University of KwaZulu-Natal
DoH:	Department of Health
DALYs:	Daily Adjusted Life Years
HIV:	Human Immunodeficiency Virus
KZN:	KwaZulu-Natal
SPSS:	Statistical Package for the Social Sciences
TDI:	Traumatic Dental Injuries
YLDs:	Years Lived with Disability

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3. **Veerasamy Yengopal:** Write-up of manuscript, data analysis - 10%

INTRODUCTION

According to estimates from the 2013 global burden of disease study, oral diseases affected 3.9 billion people between 1990 and 2010.[1] In terms of disease burden untreated dental caries in permanent teeth ranked 10th with a combined global prevalence of 35%, whilst periodontal disease ranked 6th with a prevalence of 11%, whereas tooth loss ranked 36th with a global prevalence of 2%.[1]

Oral conditions combined accounted for 15 million daily adjusted life years (DALYs) globally, 1.9% of all years lived with disability (YLDs), 0.6% of all DALYs), implying an average health loss of 224 years per 100,000 population. DALYs due to oral conditions increased 20.8% between 1990 and 2010, mainly due to population growth and ageing.[1]

Dental caries is the most common oral condition and occurs mostly in the occlusal and buccal surfaces of teeth. More than 90% of dental caries remains untreated in third world countries.[2] In South Africa, various studies have reported on the prevalence of dental caries over the years. Cleaton-Jones and Fatti reported a predominantly downward trend in the prevalence of caries in Africa particularly in the 5-6 year and 35-44 age groups despite evidence of increased sugar consumption.[3]

Findings from the 2001 South African Oral Health Survey found that almost 60% of 6-year-old children had dental caries which was above the 50% target set by the Department of Health (DoH).4 Furthermore, 80% of all dental caries in children in South Africa went untreated.[4]

Periodontal diseases include gingivitis, periodontitis, acute necrotizing ulcerative gingivitis (ANUG), HIV-related periodontitis and many other forms. Less than 15% of children aged 6-12 years old in South Africa presented with healthy periodontal status.[4] It is well known that oral health affects general health by causing pain and suffering from various oral diseases.

Oral health affects a person's physical and psychological wellbeing. For an example, severe dental caries in children affects their quality of life, as they experience pain, discomfort, disfigurement, eating and sleep disruptions, loss of school days and barriers to learning. Dental caries affects nutrition, growth and weight gain.[5]

The South African draft National oral health strategy document makes the point that the high cost of dental care, the impact it has on oral and general health and its subsequent effect on quality of life warrants that a paradigm shift be adopted in terms of policies and strategies to reduce the burden of oral disease present in our communities.

In KwaZulu-Natal (KZN), oral health services constantly experience challenges of poor prioritization, under-funding, and limited resource allocation when compared to general health services. This has caused some health facilities to report experiencing shortages of consumables, equipment and supplies, inadequate diagnostics and treatment options, long waiting lists and ultimately poor quality of health services.

In addition, there is a paucity of data with respect to the extent of the burden of oral diseases within KwaZulu-Natal. The last oral health survey in South Africa was conducted in 2001. It is therefore imperative to identify the epidemiology profile and prevalence of oral diseases in order to inform planning and evidence-based budgeting for oral health services in KwaZulu-Natal and ultimately South Africa.

This study sought to provide information on the epidemiology of some of the common oral conditions at public health facilities in two health districts in KwaZulu-Natal province, South Africa. The objectives of this study were to determine the prevalence of common oral diseases (dental caries, tooth loss, periodontal disease and trauma) among all patients attending dental clinics at public health facilities in the eThekwini and uMgungundlovu districts in KwaZulu- Natal province over a five-month period.

MATERIALS AND METHODS

This cross-sectional analytical study was designed as an audit of patient attendance and an oral disease profile over a 5 month period (November 2018 to end of March 2019) at public health facilities in the eThekwini and uMgungundlovu districts in KwaZulu-Natal province.

These two districts were selected, as when combined, they served more than 40% of the entire population of the province. These two districts also represented both urban and semi urban parts of the province and the dental clinics themselves were a combination of five primary health care facilities, one district hospital, three regional hospitals, two tertiary hospitals and one central hospital.

Sampling

The estimated combined population size for the two districts was approximately 4 million.[6] The aim was to recruit a at least 10% of the population for this study noting that almost 90% of the population use public dental facilities for their oral health needs. With this in mind, the following plan was implemented:

- The oral health team (dentists & dental therapists) at the facilities in the targeted districts were invited to a morning workshop where the aims and objectives of the study were discussed.
- The data capture form was reviewed with the clinicians who would be responsible for examining the patients and recording the data in the forms.
- Essentially, the clinicians were provided with training on the use of the ICD codes for the 16 conditions that were recorded on the data capture form. The diagnostic data collection tool also allowed clinicians space to describe any other condition that may not have been covered in the 16 conditions.
- The standard demographic information was also captured for each patient.
- All patients of irrespective of age who attended the out-patient dental and maxillofacial department (between 7 am - 4 pm) in the two districts as well as after hours in the facilities were included in the study.
- All patients or their designated guardian was required to sign informed consent in order to participate in the study.
- Patients who did not provide informed consent and those attending outside the study period were excluded from the study.

Over the 5-month period, 5600 completed records were available for analysis.

Data collection

Every patient who attended the facilities had a routine patient record file, which was opened and completed at the reception area of the clinic. The information collected included demographic variables such as age, gender, facility name, and employment status. The clinician (a qualified dentist and/or dental therapist) consulting the patients completed a standardized data extraction sheet following a routine oral health assessment.

The patient clinical information that was usually recorded for every patient was also transcribed into the data capture form by the clinician. This included information such as the diagnosis of the oral condition/s present in the patient at the time of the visit. These condition/s were recorded using the ICD-10 codes and were merely ticked off on the data capture form. An individual patient could have more than one presenting condition, e.g. caries and periodontal disease and these were ticked off on the data capture form.

No calibration was attempted in terms of the clinicians' diagnoses of the oral conditions present in the individual patients. The intention was to record their diagnoses of oral conditions during their daily routine work.

The collected data were captured and analyzed with the assistance of a biostatistician, using the SPSS statistical program. Descriptive statistics are presented as mean, range, and proportions in graphs and tables. Data reliability was ensured by clinicians going back to clinical records for any corrections. In addition patients extracted records which contained missing diagnostic data was excluded in the data analysis.

The Chi-Square Test was used to determine statistically significant associations between age, type of facility, district and most prevalent diagnosis. A 95% confidence level was adhered to for all statistical tests. A p-value of less than 0.05 was considered statistically significant.

Ethical approval was obtained from the Biomedical Research and Ethics Committee of the University of KwaZulu-Natal, reference number (BREC 386/18). Permission, consent and access to the health facilities to conduct the study were obtained from the Provincial Department of Health.

RESULTS

At the end of the 5-month study period, 5600 patients who had provided consent and received care in the facilities in both districts were included in the study and their clinical data record was included in the data analysis. Most of the patients presenting for oral health care at the identified health facilities in both districts were within the age group of 18-59 years (n=4352, 77.7%) (Table 1). The mean age of the patients was 33 years with an age range between 1 and 98 years. The majority (77.7%) of patients were between 18 and 59 years of age. Most of the patients were females (55%) and 45% were males. Most of the study patients were from eThekwini district (77%).

All the facilities in both districts were in urban and semi-urban areas. More than three quarters (76%) of the patients had achieved a greater than secondary level of education and 95% of them reported having access to clean water at home (Table 1).

Table 1. Frequency table of the characteristics of the sample population.

Variable		Number	(%)
Sample size N		5600	100
Age (years)	0-17	764	13.6
	18-59	4352	77.7
	≥60	484	8.6
Sex (F, n (%)		2996	54
Name of District	eThekwini	4329	77
	uMgungundlovu	1271	23
Urban/Semi urban		5600	100
>Secondary school education		4267	76
Unemployed		3681	66
Access to water		5316	95

Overall prevalence

The results from this study showed that of the total sample of 5600 patients, dental caries was the most prevalent oral condition at 66.4% (3719) (Figure 1), followed by periodontal disease at 11.7% (653), trauma at 7.3% (411) and lastly tooth loss at 5.9% (331).

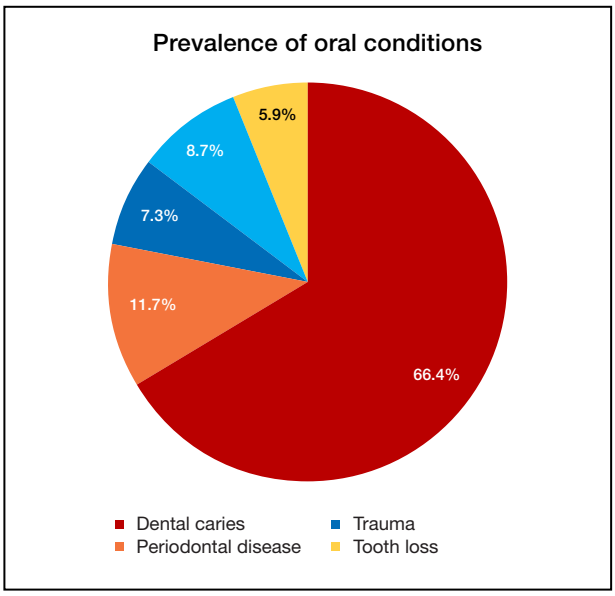

Figure 1. Combined prevalence of oral conditions in the eThekwini and uMgungundlovu districts of KwaZulu-Natal, South Africa.

Dental caries

Three thousand, seven hundred and nineteen patients (66.4%) presented with dental caries (Figure 1). Dental caries was significantly higher among the adult population of 18-59 age group at 85% (3163) $p<0.001$ compared to the rest of the age categories (Table 2).

Females had significantly higher dental caries rates of 56% (2092) $p < 0.001$ compared to males, whilst eThekwini district had significantly greater proportion of dental caries at 71% (2639) $p<0.001$ compared to uMgungundlovu district.

Periodontal disease

Six hundred and fifty-three patients (11.7%) presented with periodontal disease (Figure 1). Periodontal disease was significantly higher among the adult population of 18-59 age group at almost 78.6% (600) p<0.001 compared to the other age categories (Table 2).

Females had higher periodontal diseases rates of (373) 57% p<0.001 when compared to males, whilst eThekwini district had significantly greater proportion of patients with periodontal disease (653) 96.6% p<0.001 compared to uMgungundlovu district.

Trauma

Four hundred and eleven patients presented with trauma (411) 7.3% (Figure 1). Trauma was significantly higher 62.7% (282) p<0.001 in the younger age group of 0-17 compared to the other age groups (Table 2). Trauma was found to be significantly higher levels among males (268) 65.2% p<0.001 compared to females. There were significantly higher levels of trauma 85.1% (411) p<0.001 in eThekwini compared to uMgungundlovu.

Tooth loss

Three hundred and thirty one (331/5.9%) patients presented with tooth loss. Figure 1. There was a significant high levels of tooth loss in the 18-59 age group at 48.6% (161) p<0.001 compared to the other age group (Table 2). Males were found to have significantly higher levels of tooth loss 56.5% (187) p<0.001 compared to females. Significantly higher levels of tooth loss were found in eThekwini 59.8% (198) p<0.001 compared to uMgungundlovu district.

DISCUSSION

This study provided an epidemiological profile of oral diseases among patients who attended dental facilities in the eThekwini and uMgungundlovu districts of KwaZulu-Natal over a 5-month period. It is worth noting that there was enormous co-operation from both staff and patients involved in this study.

Although we did not track non-respondents, meetings with the clinicians involved in the data collections indicated that very few (less than 5%) of patients who attended for treatment at the study facilities did not give consent for their information/records to be used in this study.

The KwaZulu-Natal Department of Health annual report described the headcount for clinic attendance in previous years in these districts to have been approximately 2000 per month.[7] This study managed to capture 5600 patient's records who visited the facilities in 5 months.

The results of this study provide an interesting picture of the prevalence of oral diseases in the eThekwini and uMgungundlovu districts of the KwaZulu-Natal province of South Africa, its distribution across the 3 age ranges and the profile of patients seen in these public oral health facilities.

Dental caries remains the most common oral disease in KwaZulu-Natal province which is consistent with reports on the occurrence of oral disease in other provinces in South Africa.[8] This is also supported by a myriad of stu-dies undertaken in both developed and developing countries which showed a mixture of high prevalence on dental caries as well as a constant presence of this chronic condition.[9-11]

The results indicate that patients sought dental treatment primarily for the relief of pain associated with dental caries. This was based on their main complaint of dental caries being the highest diagnosis recorded. This finding is consistent with other studies.[4,12]

Furthermore, it also provides evidence that although dental treatment at most of these facilities was free or heavily subsidized, patients continued to access treatment only in the symptomatic phases of the disease when pain becomes the driving force that they seek relief.

Dental caries is a slow progressive disease that can easily be managed in the early stages which can result in the restoration that will save the tooth. There appears to be either an attitude or knowledge (poor attitude and knowledge) problem from the patient's perspective or an access and type of service problem from the facility perspective.

The implication of these findings is that the prevalence of dental caries might actually be increasing in the 18-59 and >60 age group and is contrary to the results obtained in the 2013 global prevalence of dental caries study.[1]

The prevalence of dental caries in this study also differs from the global statistics as estimated during the global review which found the prevalence of dental caries among the adult population to be 35%.[13]

Table 2. Frequency, Percentage and Chi-Square test table on the most prevalent oral conditions by age, gender and district.

Variables		Dental caries		Periodontal disease		Trauma		Tooth loss	
P values		<0.001		<0.001		<0.001		<0.001	
N/% scores		Number	Percent	Number	Percent	Number	Percent	Number	Percent
Age	0-17	233	6.3	53	8.1	282	62.7	37	11.2
	18-59	3163	85.0	600	78.6	129	31.4	161	48.6
	>60	323	8.7	153	13.2	68	5.8	133	40.2
Sex	Male	1627	43.7	280	42.9	268	65.2	187	56.5
	Female	2092	56.3	373	57.1	143	34.8	144	43.5
District	eThekwini	2639	71.0	653	96.6	411	85.1	198	59.8
	uMgungundlovu	1080	29.0	43	3.4	189	14.9	133	40.2

The combined prevalence of dental caries in this study was 66.4% which was higher than that found in a study done in 2017 in Limpopo province, which assessed the epidemiological profile of patients utilizing public oral health services, and found a 60% prevalence.[8] The findings in our study are similar to another recent cross sectional study in 2020 which looked at prevalence of dental caries among prisoners in the 18-75 age group in all 11 KZN districts. This study found a dental caries prevalence rate of 64.34%.[18]

It also appears from this study that carious lesions increase with age and that they remain problematic in adults as demonstrated here by an increase from around 30.5% in the younger age group of 0-17 years to 72.7% for the 18-59 age group. One of the specific observations from this study is that all the patients were from urban and semi-urban areas with no rural patients, this is different from other studies which had varying distribution of patients between urban and rural areas.

The number of individuals younger than 18 years in both districts according to the latest population census data is approximately 1 000 000, 26%.[6] However, when one examines the patient profile of clinic attendees, it was concerning that children made up only 15% (856 out of the 5600) of the total number that visited dental health facilities. When one compares the prevalence rates of caries among children as reported in the children's national oral health survey, there is evidence, for example, that more than 50% of children under the age of 15 years have tooth decay.[4]

This implies that children should form a much larger percentage of the population that seek care for treatment of dental caries. However, out clinic attendance rate of 15% shows that children are either not attending or access is a problem especially when one considers that free care is available for this group at most dental clinics in the public sector in KZN. The overall findings from this study has important implications for oral health planning in the province.

Periodontal disease

Periodontal disease in this study was found to have a prevalence rate of 11.7% which was similar to the study done in 2017 in Limpopo which also found a 11.0% prevalence of periodontal disease.[8] In a systematic review of the global epidemiology of dental caries and severe periodontitis conducted in 2017, periodontitis was the sixth most prevalent condition and affected 10.8% or 743 million people aged 15-99 years worldwide.

This study reported that severe periodontitis in the global population had remained static over the previous two decades at 11.2% in 1990 and 10.5% to 12.0% in 2010.13 The results of this systematic review used a more robust methodology of age-standardized methods and adds support to our findings.

In contrast the national oral health survey found a lower prevalence of 8.3% for periodontal disease. The differences in these findings could be partly explained by the fact that the present study allowed clinicians' discretion and clinical judgment to define periodontal diseases as the presence of both or either gingival and periodontal diseases whereas the national survey used the presence of deep pockets as a proxy for periodontal disease. It is worth noting that there are other international surveys which demonstrated that the prevalence of pocketing of 6 mm or more is between 5% and 20% for much of the world's population.[14]

A recent study conducted in 2019 in KZN exploring oral health status of pregnant woman found evidence of periodontal disease related conditions such as gingival inflammation, pregnancy epulis 8,5%, oral lesions 14.7%, and tooth mobility 5.9%.[19] Early oral health screening during pregnancy can ensure the overall well-being of both the mother and the foetus.

Another national survey of employed adults found the prevalence of gingival bleeding was 44%, the prevalence of pocketing of 4 mm or more was 14%, and the prevalence of attachment loss of 3mm or more was 44%. This study also found that there are other risk indicators for a higher prevalence of periodontal disease which include increasing age, poor education, lack of professional dental care, previous periodontal destruction, tobacco use, and diabetes.[14] In support of this study, our study also found a significant association between age and periodontal diseases. This study found a 78.6% prevalence of periodontal diseases among the 18-59 years adult population $p<0.001$ compared to the other age groups.

Trauma

This study found a prevalence of 7.3% for dental and maxillofacial trauma, which is similar to an average of 8%, reported in a study conducted in Johannesburg in the year 2000, in patients treated for maxillofacial injuries.[4] This study further found that of the 8% injuries, 48% were as a result of fights, assaults and gunshots. A limitation of our study is that trauma cases were pooled together and the reasons for the trauma were not listed. A study which was done in 2017 looked at the profile of 5 district hospitals providing oral health in Limpopo and found a 7% prevalence of patients with dental trauma in 500 patients clinical charts.

It further found a 4% prevalence of dental trauma in the younger group under the age of 19 years.[8]

One of the possible explanations for our study finding a slightly higher prevalence of trauma could be partly explained by the inclusion of both dental and maxillofacial trauma, as opposed to the Limpopo study which seem to have looked at only dental trauma. Another possible explanation is that the two biggest referral maxillofacial centers in the KwaZulu-Natal province are located within the two districts of our study focus.

Our study also included the three largest tertiary referral health facilities in KwaZulu-Natal, namely, Greys Hospital, King Edward and Inkosi Albert Luthuli Central Hospital in the sample as opposed to the Limpopo study which only looked at district hospitals.

Our study also found a significant difference in trauma among the males and females as well as the two districts. eThekwini had the higher prevalence rate 85,1%, p<0.001. Both districts are urban and semi urban populations, a possible explanation for a higher prevalence in eThekwini could be purely as a result of a higher population in eThekwini almost 4 000 000 compared to uMgungundlovu almost 1 000 000 population, which means that eThekwini had almost 3 times more people than uMgungundlovu.[6]

There are many studies that support the notion that males are more at risk of trauma compared to females, possible explanation of the gender differences is the risky behavior that males often engage in, however it is difficult to explain the reason for this study finding higher rates of trauma in the younger age group. One possible explanation could be that the definition of trauma in this study allowed for both dental and maxillofacial trauma. It is possible that part of the trauma related to falls, tooth trauma, assaults and injuries.

A study of traumatic dental injuries (TDI) among 4-15 years old children in India found a prevalence of 4.15%. The maxillary anterior teeth accounted for 95.45% of the TDI injuries. Maxillary central incisor was the most common tooth to be affected due to trauma (54.5%). Enamel with dentin fracture with pulp exposure was the main type of TDI (43.1%).[15] Although our study did not differentiate the type of injuries like the India study, our findings are similar to this study if you combined their findings according to the various types of injures.

Literature suggest that TDI are common in children.[16] There are few data on prevalence of TDI in South African populations. In a south African study that assessed TDI of permanent incisors in 11 to 13-year-old South African schoolchildren the prevalence of TDI was 6.4%. Falls were the main cause of TDIs, playing sports was the second most common cause and the third most common cause was collision with objects.[16] Overall the findings of our study are similar to other studies. Our study did not differentiate the type of injuries and grouped together both dental and maxillofacial injures. We would suggest that future studies could explore this further in this age group of 0-17 years as to the reasons for the injuries.

Tooth loss

This study collected data from the various age groups in order to explore tooth loss among the different age groups. This study found an overall prevalence of tooth loss at 5.9%. Tooth loss is often associated with advancing age as such our study explored this phenomenon and found that the 18-59 years group had a prevalence of 48.6% and the 60 years and above age group had a prevalence of 40.2%.

The Van Wyk study found an overall prevalence of tooth loss to be 12.6%.[4] Van Wyk study also found that there were other regions within provinces such as the Western Cape, which had a prevalence, as high as 51.6%.[4] The high number of tooth loss was also found in a recent cross sectional study in 2020 which looked at prevalence of missing teeth among prisoners in the 18-75 age group in all 11 KZN districts. This study found a tooth loss prevalence rate of 71, 85%.[18] This supports the notion that some categories of the population can have very high tooth loss rates.

It would seem from these findings that KwaZulu-Natal had the lower prevalence of 5.9% compared to the national average of 12.6%. This is an important finding in this study that needs to be explored further as to the reasons for the lower prevalence, what are some of the protective factors that may be contributing to this fact.

There seem to be global differences in tooth loss. The findings in this study as well as the Van Wyk study showed a higher prevalence of between 5.9-12.6%. In contrast to this, there are other global studies done in a 2014 systematic review of global burden of severe tooth loss, which reported a general global prevalence of 2.5% tooth loss.[17]

This global prevalence represented both developed and developing countries. We would like to explore possible factors such as diet, oral hygiene status, health system, socioeconomic status that may be possible factors to these differences in tooth loss.

Another factor worth noting in our study is that the data collected were not disaggregated into the various racial groups in south Africa, whereas the last oral health survey had explored tooth loss in the different racial groups in south Africa. In doing so it found that the colored community had as high as 51% prevalence. There is anecdotal knowledge of the specific cultural behavioral phenomenon reported in some parts of the colored community in the western cape such as deliberately removing the front teeth, thus contributing to high levels of tooth loss, it would be of interest to explore tooth loss and this racial behavioral aspect in future studies and compare to the van Wyk study.

The overall contribution of this study in the tooth loss debate suggests that although KZN had a lower rate than the National rate, tooth loss remains a health challenge among the adult population in both the 18-59 and above 60 years age groups. This challenge needs to be addressed, one possible explanation is that there may be a relationship between the high prevalence of dental caries as demonstrated in this study, patients maybe seeking treatment late and resorting to clinicians performing dental extractions treatment which in turn also contributes to the tooth loss phenomenon in the adult population.

Limitations

The main limitation of this study is that oral conditions were diagnosed according to the clinicians' perspective, i.e., there was no attempt to standardize diagnostic criteria and no calibration of clinicians' were undertaken. This could have led to an over or under-estimation of the disease profiles reported. It may be interesting to compare these oral disease profiles against one in which clinicians were calibrated and standardized for diagnos-

ing common oral conditions. It would provide evidence of an over/under estimation of oral diagnoses in this setting.

In terms of trauma data collected in this study, selection bias could have been possible as the three largest dental and maxillofacial referral facilities in the entire province reside within the study population, this may have affected the trauma prevalence indicator. This study also attempted to examine the data based on the type of facility, it was noticed that all the facilities which responded were based in urban and semi-urban areas.

As such it was not possible to include the rural vs. urban prevalence data in this study. It may be useful in future studies to compare rural and urban settings against these 4 most prevalent conditions found in this study. Another limitation of our study is that trauma cases were pooled together irrespective of the type of trauma. This may affect the comparison of trauma prevalence rates in literature, it may be useful in future studies to explore the trauma indicator in more detail.

CONCLUSION

The findings of the current study contributed to knowledge in the province in determining the four most prevalent conditions as serious dental public health challenges facing the major urban and semi-urban population in KwaZulu-Natal.

The findings have also pointed out the disease profiles affecting both males and females as well as eThekwini and uMgungundlovu districts. It is hoped that these findings will therefore be useful to policy makers to develop more responsive preventive and dental treatment services plan for the adult population of KwaZulu-Natal.

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Giant cell lichenoid stomatitis
- An oral medicine case book

SADJ November 2020, Vol. 75 No. 10 p550 - p552

L Robinson[1], L Kotze[2], WFP van Heerden[3]

CASE REPORT

A 53-year-old female patient presented with a two-week history of intermittently painful oral mucosal lesions when eating spicy, salty or sour foods. The patient reported a long-term history of psoriasis treated by topical corticosteroids only. The remainder of the patient's medical history was unremarkable. On intraoral examination, lesions were noted bilaterally in the posterior buccal commissures, appearing as centrally erosive lesions bound by white striations (Figure 1). Additionally, there were areas of desquamative gingivitis in the anterior maxillary gingiva. The clinical suspicion was that of oral lichen planus or oral lichenoid lesions. An incision biopsy from the left buccal mucosa was performed and submitted for histological assessment.

Figure 1. Initial clinical presentation: Left (A) and right (B) buccal mucosae with erosive lesions bound by white striae.

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Author contributions:
1. **Liam Robinson:** Principle author - 40%
2. **Leande Kotze:** Clinical case and treatment - 20%
3. **Willie FP van Heerden:** Diagnosis, histological images, advisor - 40%

Pathologic findings

The specimen consisted of an elliptical mucosal biopsy measuring 4 x 4 x 2 mm. Histological evaluation showed a tissue fragment surfaced by atrophic parakeratinising stratified squamous epithelium. The basal cell layer showed areas of vacuolar degeneration with focal Civatte and colloid bodies.

The lamina propria revealed a dense band-like inflammatory cell infiltrate with isolated lymphoid follicles, some with activated germinal centres (Figure 2). This infiltrate consisted of a mixed population of inflammatory cells including lymphocytes, histiocytes and scattered plasma cells. Of note, the infiltrate contained an unusual population of multinucleated giant cells (Figure 3).

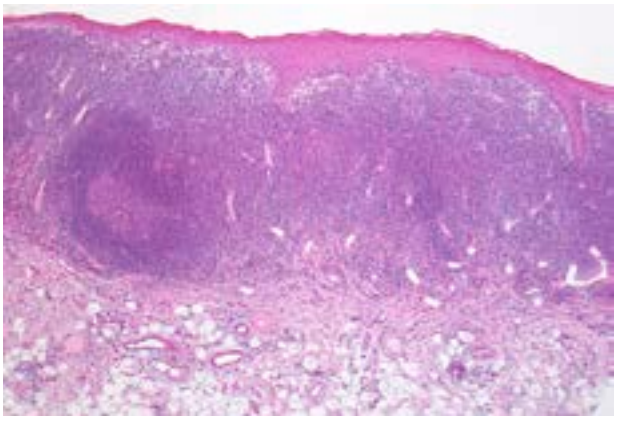

Figure 2. Low-power hematoxylin and eosin (H&E)-stained section showing the dense lichenoid inflammatory cell infiltrate with isolated lymphoid follicles (original magnification x 40).

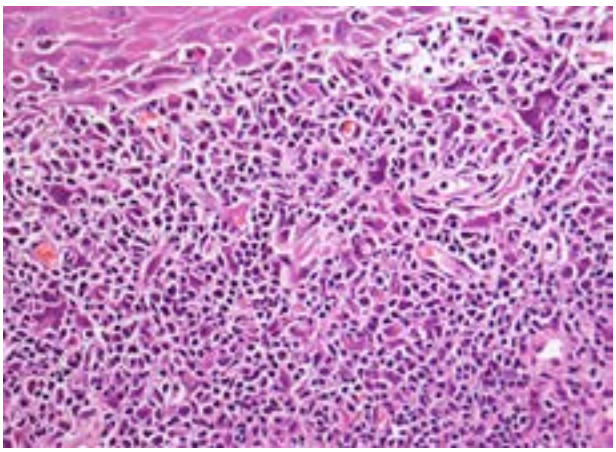

Figure 3. High-power H&E-stained section demonstrating the subepithelial giant cells (original magnification x 200). .

No evidence of granulomatous inflammation or polarisable foreign body material could be identified. No fungal

elements or acid-fast bacilli were identified on special histochemical stains. A S100 immunohistochemical stain highlighted numerous dendritic cells, but was negative in the multinucleated giant cells. A CD68 immunohistochemical stain highlighted the multinucleated giant cells (**Figure 4**).

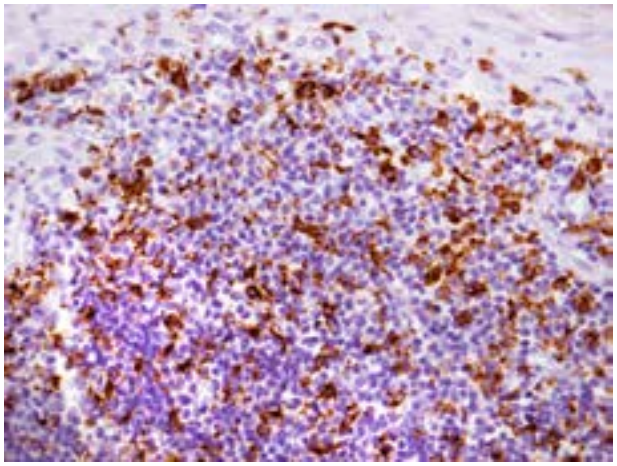

Figure 4. CD68 immunohistochemical stain confirming the histiocytic nature of the giant cells (original magnification x100).

An online literature search followed, whereby no reported cases of oral lichen planus or oral lichenoid lesions with multinucleated giant cells could be found. Several case reports of lichenoid granulomatous stomatitis with associated giant cells were referenced, however this entity was excluded in the current case due to the lack of granulomatous inflammation. A rare dermatological entity termed giant cell lichenoid dermatitis was mentioned in isolated papers, showing histological features similar to those described in the current case, most notably the presence of numerous multinucleated giant cells.

Following the literature search, the case was reported as giant cell lichenoid stomatitis, with a comment that the histological features mimic those of the dermatological entity, and may therefore be considered as an analogous mucosal entity.

DISCUSSION

Oral lichenoid lesions (OLLs), also termed oral lichenoid reactions (OLRs), are intraoral white lesions with a reticular, striated appearance, clinically similar to oral lichen planus.[1] OLLs are considered an allergic response by the oral mucosa to dental materials, certain systemic medications, patients with graft-vs-host disease and patients with certain systemic diseases.[2] OLLs represent a frequent oral condition, with a prevalence of 2.4% in the general population. They generally occur in adult patients with a mean age of 53-years and a female predominance.[2] The lesions are mostly present on the buccal mucosa, lateral border of the tongue and oral mucosa of the lips. Generally, the lesions are unilateral, an important feature distinguishing OLLs from oral lichen planus (OLP). Microscopically, OLLs and OLP show similar histological features, and cannot be easily differentiated.[1-2] A band-like inflammatory cell infiltrate subjacent to the basal cells with associated basal cell vacuolar degeneration and apoptotic keratinocytes are features shared by both conditions. Subtle differences between the two entities include a more diffuse, mixed inflammatory infiltrate with a perivascular distribution seen in OLLs.[3] Other common conditions with histological features mimicking OLP/OLLs include lupus erythematosus, chronic graft-vs-host disease and oral dysplasia.[1,3] The malignant potential of OLP/OLLs is challenging due to their overlapping histological features, and the presence of a "lichenoid" inflammatory infiltrate commonly seen in dysplastic lesions. However, two recent systematic reviews showed that OLP had a malignant transformation rate of 1.09% and 0.9%, whereas the rates for OLLs were 3.2% and 2.5%, respectively.[4]

Lichenoid granulomatous stomatitis (LGS) was first described in 2006 by Robinson et al. Histologically, LGS consists of three distinctive components. First, is the presence of lichenoid inflammation, characterised by hyperkeratosis, basal cell degeneration with associated apoptotic bodies and a band-like lymphohistiocytic inflammatory cell infiltrate. Secondly, variable degrees of granulomatous inflammation can be seen in the lamina propria consisting of epithelioid macrophages without giant cells or areas of necrosis. Thirdly, lymphoid follicles are present showing a prominent perineural distribution.[5] As previously mentioned, this condition was excluded in the current case due to a lack of granulomatous inflammation.

The term giant cell lichenoid dermatitis (GCLD) was first coined by Gonzalez et al. in 1986 as an unusual drug reaction.[6] The patient in this original case report was a 52-year-old female who presented with a generalised pruritic eruption involving the trunk and extremities, with sparing of the palms, soles, face and mucous membranes. At the time of presentation, the patient was taking prednisone for systemic lupus erythematosus (SLE) and methyldopa and chlorothiazide for hypertension. Microscopic examination of skin punch biopsies showed a band-like chronic inflammatory cell infiltrate in the papillary dermis consisting of lymphocytes, histiocytes, and occasional plasma cells. A striking feature was the presence of numerous multinucleated giant cells. The epidermis showed alternating areas of atrophy and acanthosis with focal areas of vacuolar degeneration. Drug intake as an aetiological agent was supported by the fact that there was clinical improvement following discontinuation of the chronic medications the patient was taking.[6-7] In this original case report, the authors postulated that the cause of the giant cells might be related to an impaired immune system due to longstanding SLE and low-dose corticosteroid administration.

Goldberg et al. further expanded on the condition with a report of three additional cases of GCLD.[8] Notably, all three patients were in their 6th-7th decades of life and reported a history of chronic medication usage. Their cases differed slightly from the original report, as only one case demonstrated eosinophils in the inflammatory infiltrate. One of the patients in this series developed sarcoidosis, prompting the authors to examine these two entities in further detail. Both GCLD and sarcoidosis of the skin show similar clinical and histological features.[7] Although cutaneous lesions are rare in sarcoidosis, they generally present with purple to

brown papules and plaques, however, cases presenting with a pruritic scaly rash have also been described.[8] Histologically, sarcoidosis of the skin is characterised by so-called naked granulomas containing multiple multinucleated giant cells in a lichenoid pattern at the dermo-epidermal junction. These features show some degree of overlap with GCLD, however GCLD lacks the characteristic granulomatous inflammatory component.[7] The importance of considering sarcoidosis as a possible diagnosis for GCLD lies in its association with systemic disease. The authors concluded by emphasising the importance of a clinical work-up to exclude sarcoidosis in all patients with clinical and histological features of GCLD.[8]

GCLD has also been reported in a patient with Baboon syndrome (symmetrical drug-related intertriginous and flexural exanthema) three days after administration of intravenous amoxicillin-clavulanic acid.[9] Cordoba et al. described a patient with acute lymphoblastic leukaemia who developed GCLD limited to the site of scar formation following herpes zoster resolution.[10] In both case reports, authors suggested that a hypersensitivity reaction could have played a role in triggering the condition, supporting the view of Gonzalez et al.[7,9-10]

CONCLUSION

In summary, the current case showed histological features of a mixed lichenoid inflammatory infiltrate with multinucleated giant cells, in the absence of infective aetiological agents and without evidence of granulomatous inflammation, and is therefore best termed giant cell lichenoid stomatitis. It is proposed that this entity should be considered analogous to a rare dermatological condition, giant cell lichenoid dermatitis, which shows similar histological features. Although the patient reported no history of medication usage, the concurrent psoriasis provides possible evidence of a dysregulated immune system that could account for the development of the current mucosal lesions. Unfortunately, due to limited reported cases, the clinical relevance and treatment implications of this entity are currently unclear.

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Fracture of endodontic instruments - Part 1: Literature review on factors that influence instrument breakage

SADJ November 2020, Vol. 75 No. 10 p553 - p563

M Pillay[1], M Vorster[2], PJ van der Vyver[3]

INTRODUCTION

Instrument fracture is a serious complication during endodontic treatment of teeth, having an adverse effect on the outcome of the nickel titanium (NiTi) treatment, especially if the fracture prevents apical access to the infected root canal. Despite the advent of NiTi files, the risk of fracture during the endodontic preparation of root canals, especially in severely curved canals, remains a serious concern. The fracture of NiTi files during preparation may result in a compromised prognosis for the tooth. In the presence of periapical lesions, instrument fracture may reduce the chances of successful healing.[1]

It is noticed clinically that when an instrument fractures in a root canal system, it is often associated with incomplete root canal obturation, ineffective coronal seal or poor definitive restorations (Figures 1 and 2). This further leads to micro-organisms penetrating the root canal system, indicating the development of a periapical lesion and treatment failure.[2,3]

Fractured endodontic instruments may include endodontic files, Gates-Glidden burs, lateral or finger spreaders or spiral fillers manufactured from stainless steel, NiTi or carbon steel.[1] According to a limited number of studies, the fracture incidence of rotary NiTi files ranges from 0.4 to 5%,[4,5] with the higher percentage representing fractures in molar teeth only.[4] In a majority of cases instrument fracture results from incorrect use or overuse, occurring most frequently in the apical third of the root canal.[6]

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Figure 1. Periapical radiograph of a maxillary right first molar with a fractured instrument in the disto-buccal root canal system. Note the poor canal preparation and obturation in the palatal and mesio-buccal root canal systems that resulted in extensive periapical pathology.

Figure 2. Periapical radiograph of a mandibular left first molar with several fractured instruments in the mesio-buccal and mesio-lingual root canal systems. Note the absence of root canal treatment in the distal root before post placement, with an inadequate coronal restoration with extensive decay leading to coronal leakage and periapical infection.

Rotary NiTi files are known to fracture without any visible signs of deformation and potential fracture, compared to the evident warning signs seen in traditional stainless steel files.[7]

New studies indicate that instrument fracture has many variables, the most crucial being the clinician's skill.[8] A study by Arens et al.[9] reports that 0.9% of brand-new NiTi instruments fractured during their first use, conceivably due to a manufacturing defect or misuse.

As a result of their improved designs and cross-sections, endodontic instruments subjected to torsional and flexural loads may have an altered resistance to fracture.[10,11] The low tensile strength and yield of NiTi instruments (compared to stainless steel instruments) results in a higher fracture risk at lower loads.[12] Fracture incidence of rotary NiTi instruments is significantly influenced by the clinician's proficiency with instruments and the number of uses of the instrument.[8,13]

The success of endodontic treatment may be influenced by the fracture of NiTi files. The last decade has seen instrument manufacturers make modifications to NiTi alloy to reduce the incidence of instrument fracture. The removal of a fractured endodontic file is technically challenging and time intensive, hence it is crucial to limit the probability of instrument fracture.[14]

There are conflicting results from studies on the overall outcomes and successes of endodontic treatment when a fractured endodontic instrument is left within the root canal. A study by Spili et al.[1] investigated the impact of instrument fracture on the outcome of endodontic treatment, and found that in certain cases whena fractured endodontic instrument remained in the tooth, there was no significant difference in the outcome of non-surgical root canal treatment and retreatment. However, the presence of a pre-operative periapical lesion was a more clinically significant prognostic indicator than a fractured instrument per se.

The fracture of endodontic rotary instruments can be broadly classified into two types: fractures due to cyclic fatigue and fractures due to torsional fatigue.[15] Fatigue has been implicated as one of the key reasons for endodontic instrument fracture.[16,17]

Cyclic fatigue

Cyclic fatigue is a major cause of separation of NiTi rotary instruments during clinical use.[16] Cyclic fatigue occurs because of tension–compression stress cycles at the point of maximum flexure.[18] Cyclic fatigue resistance is measured either by the number of cycles to fracture or the time until fracture.[19] The repeated extension and compression of an instrument in a curved canal may cause work hardening of the alloy, thereby creating cyclic fatigue and increased fracture risk.[20]

Cyclic fatigue fracture occurs fundamentally as a result of overuse of the NiTi alloy. Other potential factors that contribute to metal alloy fatigue include changes due to thermal expansion and contraction, as well as corrosion.[21] Factors such as the alloy, kinematics, metallurgical properties and operational settings of the instrument contribute to cyclic fatigue resistance.[22]

New concepts and designs in NiTi alloys, including thermomechanical improvements, have improved their cyclic fatigue resistance.[23] The cyclic fatigue resistance of a NiTi instrument is influenced by the metal mass of the file at the point of maximum stress[24] as well as the anatomy of the root canal; the greater the canal curvature, the greater the cyclic fatigue.[25] The cyclic fatigue resistance of rotary NiTi files decreases with increasing file diameters.[8]

Torsional fracture

Torsional fracture occurs when part of the instrument binds to the canal while the shank continues to rotate.[26] The fracture occurs when the elastic limit of the alloy is exceeded. Instruments that fracture as a result of torsional stress exhibit signs of deformation such as twisting, unwinding and straightening.[21]

Instrument manufacturing processes, designs and protocols can improve resistance to cyclic stress, but not to torsional stress since it is more dependent on the operator.[27] Torsional stresses are rapidly increased with the use of a large tapered endodontic instrument in a low-tapered, unprepared root canal.[28] There is a high incidence of torsional fracture during the preparation of complex constricted root canals where the instrument is susceptible to increased torsional loads.[15]

Numerous studies have stated that NiTi instruments with lower metal mass and small cross-sectional areas usually have lower torsional strengths.[29-31] Conventional NiTi files have a higher fracture risk when exposed to torsional stresses at lower cyclic fatigue levels. NiTi instruments which have been previously used have a high fracture risk as a result of their reduced torsional stress resistance.

Factors influencing fracture resistance

1. Design and manufacture

Instrument design and cross-section are crucial factors in the resistance to fracture when the instrument is subjected to torsional and flexural loads.[10] NiTi instruments with a triangular cross-sectional geometry have been shown to possess better fatigue resistance than instruments with a square cross-section.[32]

Many methods such as heat treatment, electropolishing and alterations of the cross-section of files have been developed to prevent the fracture of NiTi rotary file instruments.[33] The use of heat treatment to transform the alloy into an altered crystalline phase structure is a cost-effective method of manufacturing NiTi instruments with superior fatigue resistance and flexibility.[34]

M-Wire is composed of 508 Nitinol, thermomechanically treated under specific tensile stresses and temperatures.[35] M-Wire instruments are manufactured by transforming NiTi wire in the austenite phase into the R-phase, a transitional phase during the transformation of martensite to austenite by heating and cooling.[36]

A study of the metallurgical characterisation of M-Wire found that it contains deformed and twinned martensite, R-Phase and austenite crystalline phases. The deformed and micro-twinned martensite is responsible for the increased strength of the M-Wire compared to the conventional super-elastic wire without martensitic structure.[37]

Numerous metallurgical laboratory techniques have demonstrated that M-Wire contains the austenite phase with small amounts of martensite and R-Phase, thus rendering M-Wire more flexible and resistant to cyclic fatigue than conventional NiTi files.[38-40]

Endodontic instruments manufactured with M-Wire exhibited better cyclic fatigue resistance than conventional NiTi alloys.[38] The increased flexibility of M-Wire can be attributed to the presence of the martensitic phase and R-Phase. The elastic moduli of martensite and R-Phase have been reported to be lower than that of austenite.[19]

A study by Bonessio et al.[41] found that M-Wire instruments demonstrated higher flexibility than conventional NiTi, which can prevent premature fracture of the instrument if there is excessive bending during rotation.

M-Wire was shown to be more flexible and harder than conventional NiTi wire, with superior physical and mechanical properties.[35,42]

In 2010, rotary NiTi instruments were developed using a proprietary thermal process called Controlled Memory (CM) technology.[43] CM-Wire (DS Dental, Johnson City, TN) is an alloy manufactured using an unique thermo-mechanical treatment that controls the memory of the instrument, resulting in superior flexibility without the shape memory of conventional NiTi instruments.[44]

Studies have demonstrated that instruments manufactured with CM technology possess superior cyclic fatigue resistance and flexibility to conventional NiTi instruments, which can be attributed to their martensitic state.[45,46]

In a study comparing the cyclic fatigue properties of Proflexendo (Nexden, Houston, TX, USA), manufactured using CM-Wire, to Profile Vortex (Dentsply Tulsa Dental, Tulsa, OK, USA) and ProTaper Universal (Dentsply Sirona, Ballaigues, Switzerland) manufactured with M-Wire, the Proflexendo exhibited significantly greater cyclic fatigue resistance. The Proflexendo demonstrated almost 500% more resistance to cyclic fatigue than the M-Wire instruments.[47]

Galal[48] evaluated the metallurgical effect on the mechanical behaviour of CM files, M-Wire files and R-phase files using finite element analysis. The study showed CM files to be more flexible and resistant to torsional stresses than M-Wire files.

A study by Shen et al.[49] reports that the triangular and square design of a NiTi instrument made from CM-Wire demonstrated a significantly increased cyclic fatigue resistance. Thus, the design of the instrument should be considered, as it is an important factor in the fatigue life of an instrument.

The distinctive gold appearance of WaveOne Gold (Dentsply Sirona) endodontic instruments is due to the heat treatment technology applied post-manufacture. The raw NiTi is heated and slowly cooled, a process which - the manufacturer claims - improves the strength and flexibility of the instruments.[50]

The heat treatment modifies the transformation temperatures (austenitic start and austenitic finish), resulting in increased strength and flexibility of the instrument.[51] The proprietary heat treatment post-manufacture results in a two-stage Austenite-R Phase-Martensite transformation, creating an austenitic matrix with finely dispersed Ti_3Ni_4 precipitates.

The manufacturer claims that this process improves the flexibility and strength of gold wire instruments.[50] WaveOne Gold, which is developed with post-machining heat treatment, exhibits greater flexibility and higher fatigue resistance than conventional NiTi and M-Wire.[52]

2. Operator experience

Operator experience is a factor that cannot be disregarded in the incidence of instrument fractures. Yared et al.[53] and Yared and Kulkarini[54] conclude that there is a greater incidence of file fracture with inexperienced and less-informed clinicians. This conclusion implies that with continued use of rotary instruments, a clinician develops an improved tactile awareness, allowing for the detection of an increase in the torsional resistance. The skill of the operator is a key factor in instrument fracture when instrument speed, sequence and canal morphology are kept constant.[55]

Numerous factors such as the design and manufacturing process, operator experience, number of uses, instrumentation technique and root canal anatomy have been implicated in the fracture of endodontic instruments.[56]

There is a perception that NiTi instruments fracture more often than stainless steel instruments. However, the fracture incidence is comparable when NiTi files are used injudiciously. Pre-emptive measures such as good technique, the experience of the clinician, case selection and limiting file re-use have been demonstrated to reduce the incidence of fractures.[21]

In numerous cases, the fracture of rotary NiTi endodontic instruments occurs as a result of excessive or improper use,[15,57] highlighting the importance of education and training in rotary NiTi instrument use.[6,58] A study by Mandel et al.[56] evaluated the influence of the operator on ProFile (Dentsply Sirona) rotary NiTi instrument fracture. The results show that there were more file fractures during the initial 'learning' phase than in the 'application' phase. This highlights the necessity of proper training and education to establish competence in using the different NiTi file systems.

3. Number of uses

The most crucial factor leading to the fracture of an instrument is metal fatigue, representative of the number of cycles an instrument can resist under a certain load.[27] The risk of instrument fracture is low when an experienced endodontist uses a new instrument. Re-using an instrument increases the risk of file separation. If the engine file is treated as a single-use file, the number of file fractures is low.[59]

In 2006, Plotino et al.[60] reported a significant reduction in cyclic fatigue resistance between a new and a used file. The study also demonstrated that rotary instruments may be safely used multiple times; however, it must be noted that the instruments were operated by an experienced endodontist.

There are a few studies which suggest that rotary instruments can be re-used in up to ten canals.[54] Other studies suggest that in certain cases such as complex, severely curved and calcified canals, the instruments should be selectively discarded after a single use.[25,61] Arens et al.[62] report a low fracture incidence rate of 0.9% in 786 new rotary NiTi instruments, which had only been used once in predominantly difficult cases in an endodontic practice.

It is recommended that endodontic instruments are used once only to reduce the chances of instrument fracture due to cyclic fatigue and eliminate cross-contamination. Another reason is the impossibility of ensuring complete cleaning and sterilisation of instruments, hence the possible presence of prion protein.[63]

4. Root canal anatomy

The success of endodontic therapy depends on thorough chemical and mechanical disinfection of the canals and the complete three-dimensional obturation of the root canal system. Knowledge of the anatomy of the root canal system is essential,[64] as its complicated individuality has a profound influence on the cyclic fatigue that instruments experience.[30]

Canal curvature is a crucial factor that affects instrument separation, with severe curvatures exerting greater stresses on instruments. An increase in the severity of the curve radius and angle around which an instrument rotates will reduce the lifespan of the instrument.[65]

The variable anatomy of C-shaped canal systems may lead to challenges in debridement and obturation of the canals.[31] Canal geometry (e.g. angle, cross-sectional diameter and radius of the curvature) has an effect on the extent of stress an instrument experiences.[66]

5. Irrigation and lubricants

The success of endodontic treatment is based on effective shaping and disinfection of canals followed by three-dimensional obturation of the root canal system.[67] Mechanical instrumentation of root canal systems alone cannot effectively disinfect them, regardless of the instruments used.

Sodium hypochlorite (NaOCl) can cause corrosion of NiTi instruments by removing nickel from the surface, causing micropitting.[68] It is postulated that microstructural defects can create areas of crack formation and stress concentrations, leading to weakening of the instrument surface.[69]

A study by Yguel-Henry and Von Stebut[70] evaluating the effect of lubrication on the cutting efficiency of K-Files and Hedstrom files shows that 2.5% NaOCl and tap-water solutions gave greater cutting efficiency than dry conditions. Peters et al.[71] evaluated the effects of lubrication on torque-generated simulated rotary root canal instrumentation using ProFile and ProTaper (Dentsply Sirona) instruments.

The results indicate that a paste type lubricant is less effective than aqueous solutions, showing undesirable effects when used with U-shaped cross-sectioned rotary instruments. A reduction in torque and force was observed when lubrication with aqueous solutions was used in root canals.

A 2006 study by Berutti et al.[72] concludes that when NiTi rotary instruments are used in conjunction with NaOCl solutions in pulp chambers of teeth restored with alloys or metals possessing different electrochemical nobility values, galvanic corrosion can occur. This phenomenon may lead to pitting and crack formation, altering the integrity of the instrument and resulting in decreased resistance to fracture as a result of cyclic fatigue.

A study by Uslu et al.[73] evaluated the effect of NaOCl and ethylenediaminetetraacetic acid (EDTA) solutions on the cyclic fatigue resistance of WaveOne (Dentsply Sirona and WaveOne Gold NiTi reciprocating files. The study showed that exposing WaveOne and WaveOne Gold files to NaOCl and EDTA solutions did not influence the cyclic fatigue resistance of the files.

6. Electrical endodontic motors

The type of electrical endodontic motor plays an influential role in the outcome achieved with endodontic instruments. Mechanical limitations of electric motors arise when converting the direction of rotation, resulting in acceleration and deceleration in both directions. It is crucial to select an appropriate electric motor for each type of file system.[30]

Low-torque or controlled-torque endodontic motors capable of individually adjusted torque limits for individual files reduce the risk of instrument fracture by keeping the file working below the limit of file elasticity, without exceeding the file-specific torque limit.

The auto-reverse function is a great safety feature; however, a certain amount of force is required to stop the rotation of the instrument, disengage it from the initial path and rotate it in the opposing direction. This force is stored within the instrument memory; hence with repeated activations of the auto-reverse function, more memory is stored, resulting in a reduction in the lifespan of the instrument.[74]

High-torque motors increase the risk of instrument fracture as the file-specific torque limit is often exceeded. The use of low-torque instrumentation demonstrated an increase in operators' tactile sensation and mental awareness of rotary instrumentation.[75]

7. Continuous rotary motion

The biggest challenge in using rotary NiTi instruments has been separating files during use, which can be attributed to their use in continuous rotation.[76] Studies have demonstrated the advantages of NiTi rotary instruments over stainless steel hand instruments. Such advantages include improved preservation of the shape and curvature of the original canal anatomy, fewer catastrophic errors and reduced treatment time.[5,77]

A study by Gabel et al.[78] demonstrates that the risk of instrument distortion and separation is four times greater at a rotational speed of 333.33 rpm than at a speed of 167.67rpm. The risk of instrument fracture is reduced at lower rotational speeds; conversely, there is increased risk at higher rotational speeds.

The advent of rotary NiTi endodontic instruments has improved the efficiency of endodontic treatment with regard to accuracy, risk reduction and procedural time.[13]

A study by Da Frota et al.[79] found that torsional resistance and cyclic fatigue were lower for instruments from continuous rotary systems than for those from reciprocating systems during instrumentation, irrespective of axial displacement.

8. Reciprocation motion

Reciprocating motion has been used for many years in endodontics.[80] It can be defined as a repetitive backward-and-forward (clockwise (CW)/counter-clockwise (CCW)) movement which can be applied to endodontic instruments, or as an oscillating motion in which an instrument rotates in one direction, reverses direction, and then completes a full rotary cycle.[81]

In reciprocal motion, the degree of rotation differs in the CW and CCW directions. There is a higher degree of rotation in the CCW direction, which is the cutting direction, allowing for the progression of the instrument in the canal and dentine removal. There is a smaller degree of rotation in the CW direction, allowing for the instrument to unlock and safely move through the canal, hence reducing the risk of instrument separation.[82]

In reciprocating motion there is reduced risk of torsional fracture, which can be attributed to the angle of the CCW rotation which is intended to be smaller than the elastic limit of the instrument.[34] The key advantage of reciprocal motion is the reduced incidence of endodontic mishaps through file separation, which can be attributed to avoiding constant dentinal over engagement. This movement minimises flexural and torsional stresses, improves canal-centring ability and decreases the taper lock of the file in the canal.[83]

In 2008, Yared[84] stated that a root canal can be efficiently shaped with a single file used in a forward reciprocating motion. The technique involved the use of a single 08 K-File hand instrument and one F2 ProTaper Universal NiTi rotary instrument in reciprocating motion. This technique also increases the cyclic fatigue resistance of the file, reduces the number of instruments required and minimises possible contamination. An extended lifespan was recorded for NiTi instruments used in reciprocating motion.[30]

A study by Hamid et al.[77] in a student clinic setting found NiTi reciprocating instruments to be superior to hybrid hand/NiTi rotary instruments in the reduction of treatment time, procedural errors and fracture incidence and the improvement of obturation length and taper. Shenouda et al.[85] evaluated the fracture resistance of WaveOne Primary, ProTaper Universal F2 and One Shape files. The results show the One Shape file to possess a significantly greater fracture resistance than the WaveOne Primary and ProTaper Universal F2 files.

It is recommended that single-file reciprocating instruments are used in only two or three root canals, depending on the complexity of the canal anatomy. Hence, the cyclic fatigue test for reciprocating instruments is vital.[86] In this study, the cyclic fatigue resistance to fracture of the WaveOne Gold and One Curve file systems were compared. The influence of glide path preparation prior to final canal instrumentation on the fracture rate and preparation times were evaluated and compared between the two systems. Final canal preparation times with the Primary WaveOne Gold and One Curve were also recorded.

The endurance limit of NiTi files may be defined as the level of torsional stress a file may be subjected to over infinite cycles without failure.[87] Torsional deformation develops on the axis of the file each time the file cuts dentine in a root canal in a rotary motion. There are no structural changes, provided the torsional deformation does not exceed the limits of plastic deformation. However, if the repeated torsional deformation is accrued and exceeds the endurance limits, the instrument will fracture due to torsional fatigue.

This mechanism of stress is supplementary to the cyclic fatigue that is created within a curved root canal. Partial or asymmetrical reciprocation is the movement where the angle of rotation is limited in the cutting verse under the endurance limit of the instrument in which the angle of rotation is higher in the cutting verse than that of the angle of rotation in the opposite non-cutting verse.[88]

Reciprocation offers many advantages over continuous rotation, such as a reduction of torsional and flexural stress on the instrument, reduced incidence of instruments binding to the canal walls, decreased risk of fracture and a reduction in the number of cycles during preparation of the root canal.[89] A study by Rubio et al.[90] shows that file systems with Gold-Wire alloys and reciprocating motion offer better resistance to cyclic fatigue than most of the continuous rotation systems evaluated in the study.

In 2010, You et al.[91] analysed the lifespans of NiTi rotary instruments during preparation of extracted molars with curved root canals in continuous rotation and reciprocating motions. A sequence of ProTaper Universal SX, S1, S2, F1 and F2 files (Dentsply Sirona) were used in continuous rotation, while a ProTaper Universal F2 instrument was used in reciprocating motion. The study reports an extended lifespan for the ProTaper Universal F2 instrument used in reciprocating motion, which was safely negotiated to working length of the canals at least six times.

A literature review by Ferreira et al.[92] finds the majority of studies suggest that reciprocating motion improves cyclic fatigue resistance better than continuous rotation, independent of other factors such as NiTi instrument design, the angle of curvature of the artificial canal and the speed of rotation. Kim et al.[30] compared the Reciproc and WaveOne reciprocating files with the ProTaper Universal F2 file in continuous rotation mode.

The results show that both reciprocating file systems demonstrate a significantly higher torsional and cyclic fatigue resistance than the ProTaper Universal F2 file. Topçuoglu et al.[93] determined that the Primary WaveOne Gold instrument exhibited greater cyclic fatigue resistance than the Primary WaveOne and Reciproc R25 instruments in artificial S-shaped canals. A study by De Deus et al.[94] compared ProTaper Universal F2 instruments in forward reciprocating motion to continuous rotation, evaluating the cyclic fatigue resistance. The results show reciprocating movement to be better at reducing cyclic fatigue and extending the life of ProTaper Universal F2 instruments than continuous rotation.

Reciprocating movement is able to prevent constant torque and continuous rotary force on the root canal wall, thus reducing dentinal damage.[95] There are inconsistent results in the literature regarding the efficacy of bacterial reduction and debris removal. The possibility of dentinal crack formation and debris extrusion during endodontic treatment with reciprocating instruments remains.[96]

In a study by Gavini et al.[97] a fatigue test was performed using the Reciproc R25 (VDW) in reciprocating motion and continuous rotation, with the instruments used in reciprocating motion taking longer to fracture. It took the instruments in the reciprocating group 357.56 seconds to fracture compared to the instruments in the continuous rotation group, which took 163.27 seconds. You et al.[91] used a ProTaper Universal F2 instrument in reciprocating motion and a sequence of ProTaper Universal SX, S1, S2, F1 and F2 files in continuous rotation during the endodontic preparation of curved root canals of extracted molar teeth. The lifespan of the files was then analysed, with an extended lifespan being reported for the reciprocating motion ProTaper Universal F2 file.

A study by Kwak et al.[98] comparing students' and novice operators' acceptance of rotary and reciprocating NiTi systems found a greater preference for reciprocating files than continuous rotation systems, and for NiTi files over stainless steel files.

A study by De Deus et al.[99] concludes that there is no causal relationship between dentinal microcrack formation and canal preparations with WaveOne, BioRaCe (FKG Dentaire, La-Chaux-de-Fonds, Switzerland) and Reciproc (VDW) systems.

Wan et al.[81] evaluated the cyclic fatigue resistance of four continuous rotation NiTi instruments, K3 (SybronEndo, Glendora, CA, USA), ProFile and GT Series X (Dentsply Sirona), and a reciprocating instrument, SafeSider (Essential Dental Systems, South Hackensack, NJ, USA) in curved artificial canals. The results show that SafeSider files have a longer lifespan than the continuous rotation instruments. A similar study compared the cyclic fatigue resistance of WaveOne used with reciprocating motion to Twisted Files (SybronEndo) and ProTaper Universal files used in continuous rotation. The study found the WaveOne instrument to have a higher cyclic fatigue resistance as a result of the reciprocating motion.[100]

Rubini et al.[101] evaluated the cyclic fatigue resistance of a size 40/04 HyFlex (Coltene/Whaledent AG, Altstatten, Switzerland) NiTi instrument used in both reciprocating motion and continuous rotation. The study found reciprocating motion improved cyclic fatigue resistance. Cunha et al.[102] postulate that the low fracture incidence of WaveOne instruments may be attributed to the reciprocating motion, metallurgy and single-use nature of the file. They conclude that the incidence of file fracture when using the WaveOne reciprocating files is very low.

A study by Gambarini et al.[23] compared the cyclic fatigue resistance between stainless steel K-Files used in a reciprocating motion and NiTi rotary PathFiles (Dentsply Sirona) in artificial curved canals. The aim of their study was to evaluate whether stainless steel instruments could benefit from a reciprocating motion and NiTi rotary PathFile instruments, during enlargement of the glide path, given that reciprocation can improve the fatigue resistance of NiTi instruments. The stainless steel K-Files used with the M4 hand piece (SybronEndo) showed a significantly greater resistance to cyclic fatigue than the NiTi rotary PathFiles.

9. Glide path

A glide path is a smooth radicular tunnel extending from the canal orifice to the radiographic canal terminus or exit as determined by an electronic apex locator.[103] The creation of a glide path ensures a patent canal permitting the safe and effective use of rotary instruments.[104]

The objective of a glide path in canal preparation is to produce a canal diameter which is the same size as, or a size bigger than, the first rotary instrument introduced.[104,105]

Peters[106] and Roland et al.[107] state that performing coronal enlargement of the root canal can reduce the risk of instrument fracture. In 2003, Blum et al.[108] suggested the creation of a glide path with small flexible stainless steel hand files to ensure sufficient space for the introduction of rotary instruments. Berutti et al.[104] recommend the preparation of a glide path by manual preflaring of the canal prior to using NiTi rotary instruments.

Various techniques and instruments have been advocated for the glide path preparation, such as manual preparation with stainless steel K-Files, a combination of stainless steel K-Files and a reciprocating hand piece, the use of a smaller tapered motor-driven NiTi rotary instrument or the use of hand files followed by rotary NiTi glide path files.[72,109-111]

In teeth with severely curved or constricted canals, using hand files has been shown to be more time-consuming.[112] A study in 2009 by Berutti et al.[113] demonstrates that glide path preparation with hand files created unwanted modification of the canal curvature and more irregularities than did preparation with rotary PathFiles (Dentsply Sirona).

In 2013, Cassim and Van der Vyver[114] concluded that rotary file systems performed better than stainless steel K-Files in a reciprocating hand piece, which in turn performed better than stainless-steel K-Files used by hand only. Once established, successful glide path preparation can reduce torsional stresses and increase the lifespan of a rotary instrument by up to six times, thereby reducing fracture risk and costs.[104]

Patiño et al.[105] show that proper glide path preparation significantly reduces the incidence of instrument separation. A study by Vorster et al.[115] shows that prior glide path preparation significantly reduces the final canal shaping time when the Primary WaveOne Gold file is used, compared to a group where no prior glide path was prepared before final canal shaping.

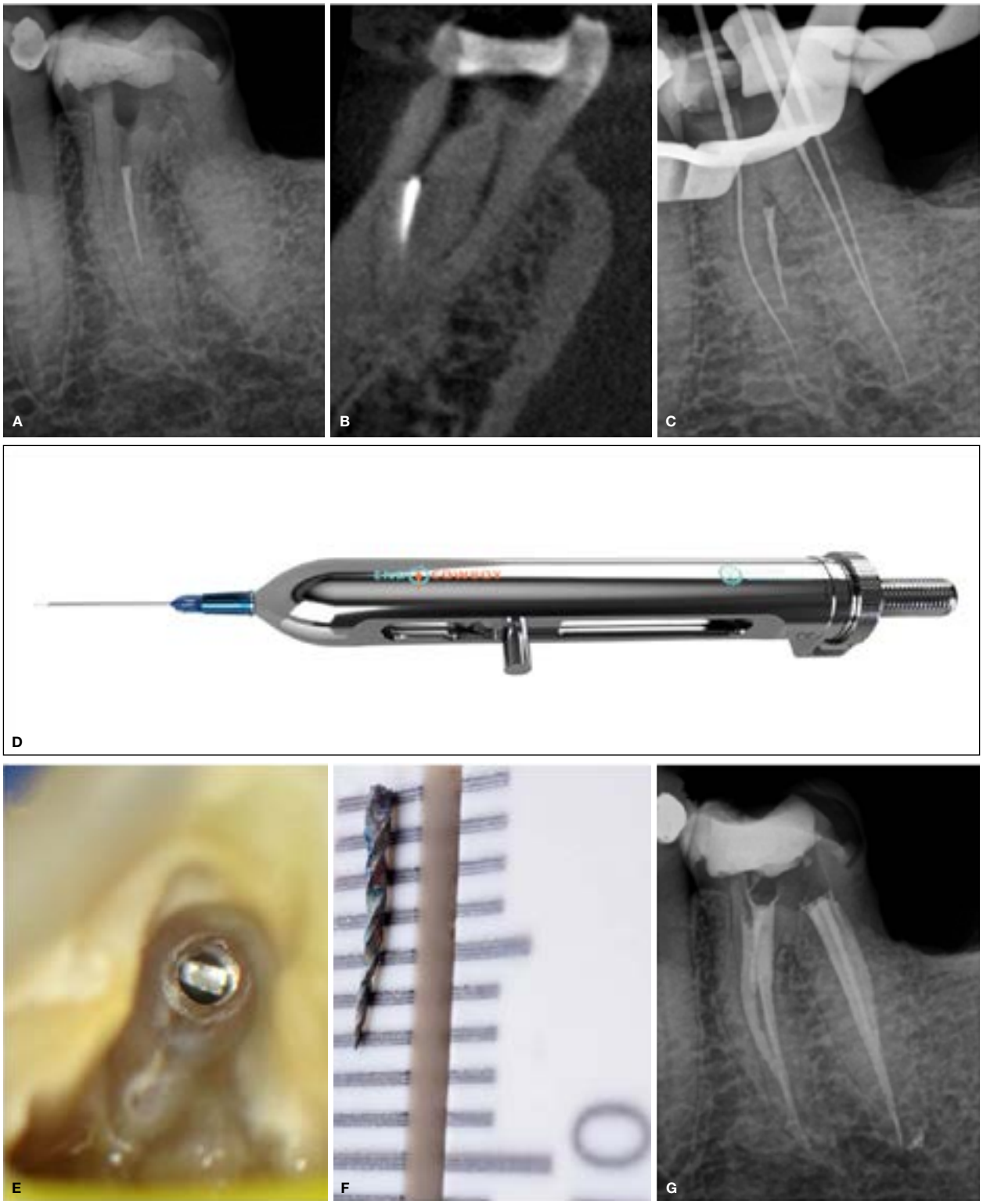

Figure 3.

A. Periapical radiograph showing a fractured instrument in the mid-root area of the mesio-buccal root canal of a mandibular left first molar.
B. Sagittal view of a CBCT confirmed that the fragment was located just below the maximum curvature of the root canal system.
C. Length determination periapical radiograph confirming that the mesio-lingual and mesio- and disto-buccal root canal systems were patent and could be negotiated to full working length.
D. EndoCowboy (Körhrer Medical Engineering), preloaded with the standard 0.12 mm wire in a 0.5 mm cannula.
E. Coronal aspect of fractured fragment in the mesio-buccal root canal system under 12X magnification.
F. Extracted fractured fragment measuring 6 mm on a ruler.
G. Postoperative periapical radiograph after root canal preparation and obturation of all the root canal systems.

The preparation of a glide path prior to the introduction of a greater tapered instrument with a large tip diameter is advocated when using NiTi rotary instruments, as it reduces the occurrence of both types of fracture.[116,117] The presence of a glide path allows the instrument to function under less torsional stress, with reduced risk of canal transportation. Glide path preparation with rotary instruments is faster, with less debris extrusion, than preparation with hand instruments.[115,118,119]

CASE REPORT

A 58-year-old male presented with a history of a fractured instrument in the mesio-buccal root canal of his mandibular left first molar. A periapical radiograph confirmed a fractured file located in the midroot region of the root (**Figure 3a**). A sagittal view of a cone beam computed tomography (CBCT) confirmed the location but demonstrated that the fragment was located just below the maximum curvature of the root canal system (**Figure 3b**). The mesio-lingual and mesio- and disto-buccal root canal systems were patent and could be negotiated to full working length (**Figure 3c**).

It was decided to use the EndoCowboy (Körhrer Medical Engineering) to extract the fractured file from the root canal (**Figure 3d**). **Figure 3e** depicts the coronal aspect of fractured fragment in the mesio-buccal root canal system under 12X magnification. A size 15 Endosonare file (Dentsply Sirona) mounted in a U-File holder (Endo Kit E12, NSK) driven by a Satelec P-5 ultrasonic Scaler (Satelec) was used to trough around and expose the coronal aspect of the fragment.

The EndoCowboy (Körhrer Medical Engineering), preloaded with the standard 0.12 mm wire in a 0.5 mm cannula, was introduced into the root canal, the preformed lasso was positioned around the separated instrument, the lasso closed and the fractured fragment (**Figure 3f**) extracted from the root canal using a pulling action. **Figure 3g** shows the final obturation result after treatment of all the root canal systems.

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Modern considerations when approaching fractured endodontic instruments - Part 2: A review of the literature and clinical techniques

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INTRODUCTION

Once root canal treatment is considered, the treating clinicians must be aware of the real possibility that complications and unforeseen accidents can occur during any stage of the treatment. Complications and accidents may include instrument separation, root perforation on different levels and ledge formation.

Once complications and accidents arise during any part of the cleaning and shaping procedure, the tooth can be compromised and the prognosis can ultimately be reduced.[1-3] The reduced prognosis may even extend to the final obturation and 3D sealing of the root canal system.[2,3]

The ultimate goals of any root canal treatment are to remove or destroy micro-organisms within the root canal system, remove necrotic or infected pulp tissue and finally achieve an acceptable obturation and sealing of all root canal spaces.[1] Where separation of endodontic instruments occurs it can create one of the most stressful and unpleasant situations for both the clinician and patient. The occurrence can have a "snowball" effect: a patient can perceive the incident as a treatment failure (even as clinical negligence if complications arise); final coronal restorability is compromised; and if medico-legal action is taken, conflict can arise between the treating clinician and referring dentist.[4]

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In the literature, instrument failures are attributed to various factors. One of these is the incorrect use of instruments; operators can ignore the techniques advocated by the manufacturers or operate instruments already fatigued by repeated use.[5,6]

Treatment considerations

Once a clinician is confronted with a fractured endodontic instrument, it is important to follow a structured approach. The clinician must realise that the treatment could be challenging and must also be aware of complicating factors, which may include:

1. the complexity of the root canal system.
2. the treating clinician's access to the materials, instruments and devices needed to attempt removal.
3. whether the clinician can predict the outcome of the attempt removal considering his or her experience.
4. the location, size, position and diameter of the fractured fragment.[6,7]

The clinician should also consider the wishes of the patient, who might decide on extraction due to financial and/or time constraints or anxiety.[4] The interests of the patient are paramount. There are also a number of clinical factors to consider before treatment is attempted:[4]

Periodontal and restorative prognosis

In general, periodontally compromised patients are not ideal candidates for instrument removal unless the periodontal health is stable and well maintained. Restorability also needs to be considered when periodontal breakdown is diagnosed.[4]

General patient factors

An attempt to remove a fractured instrument can consume clinical chair time. A patient might be apprehensive or might have time constraints.[4] On the other hand, certain medical conditions (bleeding disorders and certain medications, including bisphosphonate) may tip the balance towards removing the fractured fragment where extraction is contra-indicated.[8] Treatment costs can also

play a role, as certain cases may involve referral to a specialist endodontist or a clinician with proven experience in the field of endodontics.[4]

The following options can be considered once the decision is made to proceed with treatment:

1. Leaving the fragment *in situ*

This option involves incorporating the fragment into the final obturation.[9] Leaving a fractured instrument *in situ* can be risky in cases with apical lesions as the healing will be reduced,[2,10] but in selected vital cases or cases where advanced mechanical-chemical disinfection is available and the prognosis is considered more favourable, this treatment approach can be considered.[11,12]

CASE REPORT 1

A 23-year-old female presented with a fractured file in the mesio-lingual root canal system of her mandibular right first molar, approximately 3 mm from the apex of the root (Figure 1A). A CBCT scan revealed a large periapical lesion around the mesial root and a small periapical lesion around the distal root canal (Figures 1B and C).

An attempt was made to remove the fractured instrument using ultrasonics. After 40 minutes the attempt was unsuccessful, and a perforation was caused in the furcation area of the tooth. It was decided to leave the fractured file *in situ* and to repair the perforation with MTA (Figure 1D). The other three root canal systems were negotiated and prepared with a WaveOne Gold Primary file (Dentsply Sirona).

Root canal obturation of the other three canals was done with Primary WaveOne gutta percha cones (Dentsply Sirona) and pulp canal sealer (Kerr) using the warm vertical condensation technique. A two-year postoperative follow-up periapical radiograph (Figure 1E) and CBCT scan (Figures 1F and G) revealed good healing of the periapical pathology.

2. Bypass the fragment

In general, space can be created by inserting small hand files between the fragment and the root canal. Although a time-consuming and labour-intensive exercise, full working length negotiation can be achieved.

There is also a good possibility that the fragment can be loosened and removed during bypassing. In selected cases where no movement is achieved, the fragment can be left *in situ* and incorporated to form an integrated part of the final obturation.[9]

CASE REPORT 2

A 45-year-old female presented with a fractured file in the mesio-buccal root canal of her mandibular right

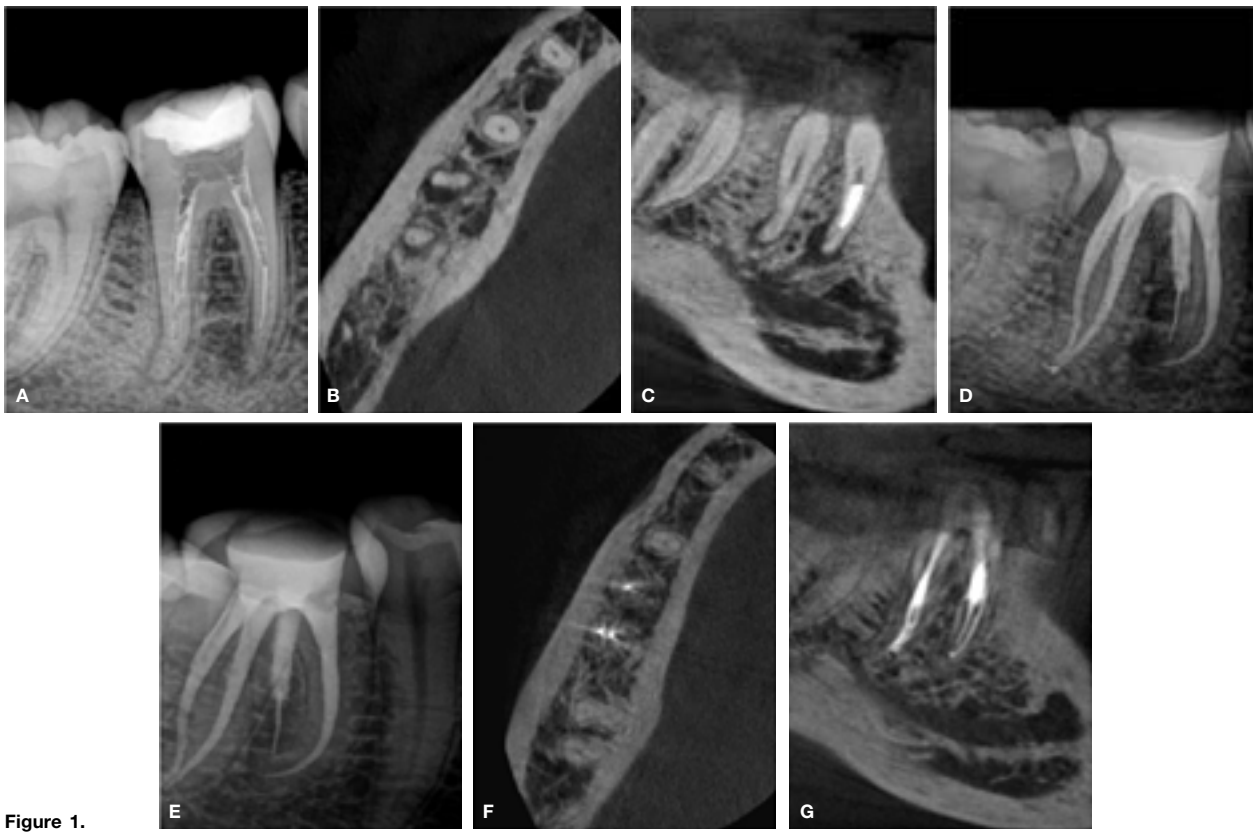

Figure 1.
A. Pre-operative periapical radiograph of the mandibular right first molar with a fractured file in the mesio-lingual root canal system.
B. Axial view on CBCT demonstrating a large periapical lesion around the mesial root and a small periapical lesion around the distal root.
C. Sagittal view on CBCT showing a large periapical lesion around the mesial root and a small periapical lesion around the distal root.
D. Repair of perforation with MTA and fractured file left *in situ*.
E. A two-year post-operative periapical radiograph.
F. Axial view on a two-year postoperative CBCT showing healing of periapical pathology.
G. Sagittal view on a two-year postoperative CBCT demonstrating healing of periapical pathology.

second molar (Figure 2A). It was a fragment of approximately 7 mm, located at the apex of the root canal system. After an unsuccessful attempt by her general dentist to remove the fragment with ultrasonic instruments, she was referred for further management.

At the time of treatment it was decided to attempt to bypass the file because (1) examination of a CBCT scan revealed that the fragment was located beyond the maximum curvature of the root canal system; (2) under high microscope magnification the coronal aspect of the fractured fragment was not visible, even after coronal enlargement of the root canal system by her general dentist.

A size 08 C+ (Dentsply Sirona) and 08 K-File (Dentsply Sirona) were precurved and used alternately to bypass the fractured fragment (Figure 2B). The new glide path next to the fractured instrument was carefully enlarged with a size 10 K-File, followed by a size 12 Profinder (Dentsply Sirona) and a ProGlider rotary glide path instrument (Dentsply Sirona) used in a manual motion.

Canal preparation was completed with the TruNatomy Prime file in the mesial root canal systems and the TruNatomy Medium file (Dentsply Sirona) in the distal root canal system. The fit of two Prime and one Medium TruNatomy gutta percha cones (Dentsply Sirona) was verified radiographically (Figure 2C) before the canals were obturated with AH Plus root canal cement (Dentsply Sirona) using the Gutta Smart Obturation System (Dentsply Sirona) (Figure 2D).

3. Removal of the fractured instrument

Attempting to remove a fractured instrument can be a very challenging exercise.[13] Hulsmann[14] states that there is no standard method of removing fractured instruments and that a number of approaches can be followed.

It must be emphasised that no matter what technique is used, proper vision, illumination and magnification play a crucial role when attempting retrieval.[15] The Dental Operating Microscope (DOM) increases direct visualisation of the instrument fragment where normal vision is inadequate.[16] A study by Nevares et al.[17] concludes that the success rate in removing or bypassing fractured instruments is doubled when the fragment is visible under the DOM.

In recent years several new techniques and devices used in the removal of separated instruments have been introduced in the market. It is important to note that the clinician's skills and experience are crucial aspects when deciding which technique is best suited for separated instrument removal. Referral to a clinician or specialist with more experience in instrument retrieval might prove a better alternative in cases where the clinician's skill is lacking. Some widely used techniques and some more recent promising techniques are discussed below.

i. Ultrasonics

Ultrasonics is probably the most widely used technique in endodontics in the removal of separated instruments. A Gates Glidden drill (GG) no.1 (0.50 mm), GG no.2

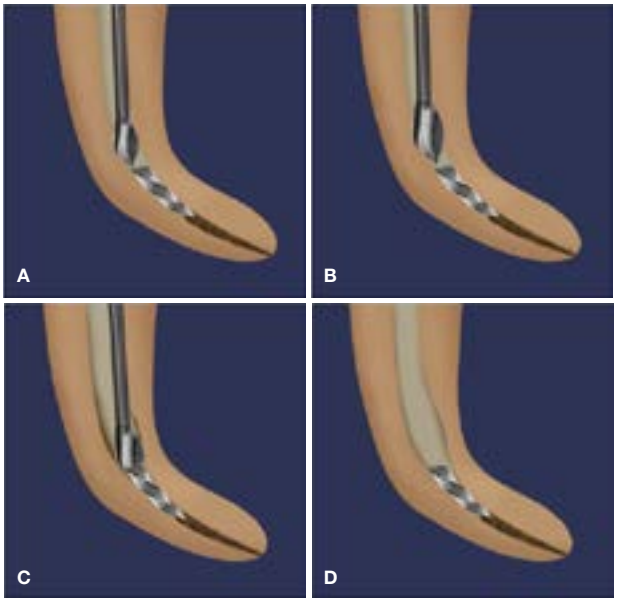

Figure 3. (Adapted from Terauchi, 2012[37])
A. GG drill no. 1 or GG no. 2 is taken to the depth of the separated instrument to create radicular access to the obstruction.
B. GG drill no. 2 or GG no. 3 is taken to the depth of the separated instrument to create further radicular access to the obstruction.
C. Creation of a staging platform with a modified GG bur.
D. Completed staging platform that allows enough space lateral to the broken file segment to initiate trephining procedures.

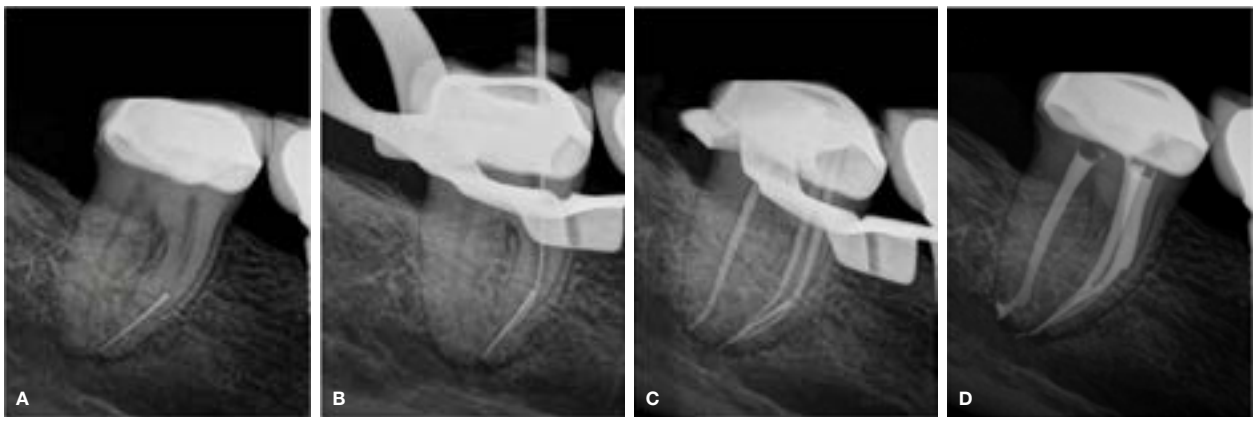

Figure 2.
A. Pre-operative periapical radiograph of a mandibular right second molar with a fractured instrument in the mesio-buccal root canal system.
B. Fractured file bypassed with a size 08 K-File.
C. TruNatomy Prime gutta percha points fitted after preparation with the TruNatomy Prime file.
D. Postoperative periapical radiograph after obturation.

(0.70 mm) or GG no.3 (0.90 mm) can usually be taken to the depth of the separated instrument to create radicular access to the obstruction (Figures 3A and B). In addition, it is recommended to create a staging platform with a modified GG bur (Figure 3C). A GG drill whose maximum cross-sectional diameter is slightly larger than the visible instrument is modified by cutting it perpendicular to its long axis at its maximum cross-sectional diameter with a diamond bur. The staging platform (Figure 3D) allows enough space lateral to the broken file segment to initiate trephining procedures with ultrasonic instruments.[18-21]

The clinician should be able to see the separated instrument with the use of magnification and illumination.[22] An ultrasonic tip is used to create a gutter around the fractured instrument before dislodging the separated portion using ultrasonic agitation. For a better view, canals should be irrigated and dried before introducing the ultrasonic tips into the canal. Ultrasonic instruments of different tip sizes and diameters that can be adapted to different sections of the root canal are commercially available.[11] Magnification is essential when using these tips, as blind trephining might lead to undesired removal of dentine along the root canal walls. Nagai et al.[23] report a 67% success rate in removing separated instrument fragments using ultrasonics; other success rates of 88%[24] and even as high as 95% have been reported.[25]

It is important to note that the use of ultrasonics can sometimes cause secondary fracture of the separated fragment (Figures 4A and B). In a study by Ward et al.,[26] where ultrasonics was used to remove separated files from simulated canals and extracted teeth, they observe that a portion of the instrument would occasionally break off from the original fragment, leaving a shorter fragment behind. In general, shorter fragments are more difficult to remove than longer ones, and the retrieval rates are low for fragments that are located apical to the canal curvature.[27-29]

Ultrasonic vibration also sometimes pushes the separated file deeper down the canal, and aggressive or incorrect use of ultrasonics sometimes results in perforation of the root canal. Another disadvantage is that the prolonged use of ultrasonics can result in a temperature rise on the root surface.[30-32] According to Sweatman et al.,[33] if the temperature increase on the root surface goes beyond 10°C the periodontal tissues can be seriously damaged, especially when the ultrasonic energy is used without coolant to enhance the view.[20,23,26,29,34]

The increase in temperature depends on the duration of activation, type of ultrasonic tip, power settings, and the use of coolants such as water and air.[27,35] A study by Madarati, Qualtrough and Watts[36] shows that ultrasonic activation with constant air flow as coolant did keep the temperature rise significantly lower than activation without the air flow during file removal attempts.

Figure 4.
A. Pre-operative periapical radiograph of a symptomatic maxillary second molar with a fractured instrument in the mesio-buccal root canal system.
B. During an attempt to remove the fractured instrument with ultrasonics a secondary file fracture was caused, leaving the retained fragment much deeper in the root canal system.

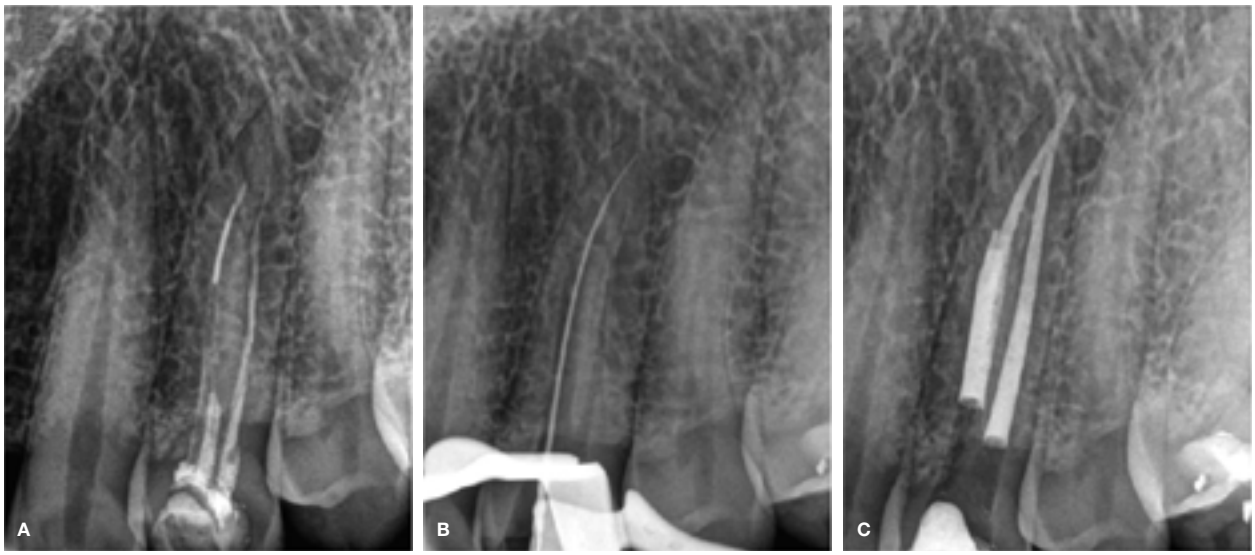

Figure 5.
A. Pre-operative periapical radiograph of maxillary left first premolar with poor root canal treatment and a fractured instrument in the buccal root canal system.
B. Fractured file was removed with ultrasonics and the canal negotiated to working length.
C. Postoperative periapical radiograph after obturation of the root canal systems.

They also demonstrate that an increase in temperature generated by ultrasonics within the canal might be several times higher than the readings recorded on the external root surface.[36]

CASE REPORT 3

A 38-year-old male presented with a history of pain and discomfort on his maxillary left first premolar. Radiographic examination revealed a previous root canal treatment on the tooth with a fractured file in the buccal root canal and inadequate root canal preparation and obturation in the palatal root canal (Figure 5A).

The existing gutta percha was removed from the root canal systems with Endosolv E (Septodont) and a size 15 Hedstrom file (Dentsply Sirona). A staging platform was prepared with a size 2 GG bur to create straight-line access into the root canal system and to expose the coronal aspect of the fractured fragment.

A size 15 Endosonare file (Dentsply Sirona) mounted in a U-File holder (Endo Kit E12, NSK) and attached to a Satelec P-5 ultrasonic scaler (Satelec) was used to trough around the fragment in a anticlockwise direction until the file was dislodged from the root canal.

The canals were negotiated (Figure 5B), glide paths were prepared and root canal preparation was completed before the root canals were irrigated with EDTA and heated 3.5% sodium hypochlorite before obturation (Figure 5C).

ii. Zumax Broken Instrument Removal Kit (Zumax Medical)

As with the ultrasonic technique, the first step in using the Zumax Broken Instrument Removal Kit (Zumax Medical) is creating radicular access and a staging platform using conventional and modified GG drills.

The next step is selecting one of the three trephine burs whose maximum cross-sectional diameter is slightly larger than the visible coronal aspect of the fractured instrument. The trephine is operated at a speed of 600 rpm in a contra-angle hand piece to remove a small amount of dentine around the fractured segment in order to expose the coronal aspect of the fragment for about 2.5-3 mm. The trephine burs are available in sizes 0.8, 1.0 and 1.2 mm in diameter (Figure 6).

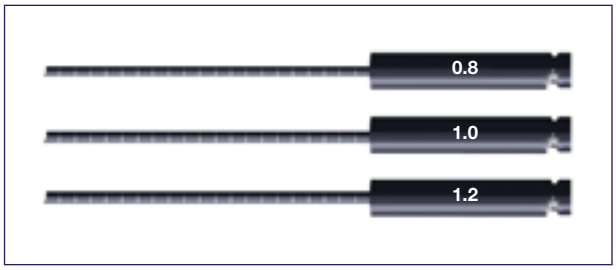

Figure 6. Trephine burs of the Zumax Broken Instrument Removal Kit (Zumax Medical) available in sizes 0.8, 1.0 and 1,2 mm in diameter.

The rest of the system comprises a stainless steel handle that can be fitted with either one of three extractors (0.8, 1.0 and 1.2mm in diameter) (Figure 7A) or a crab claw-shaped tweezer (Figure 7B). The crab claw-shaped tweezer is indicated for removal of fractured instruments that are visible directly on the pulp floor.

The extractors are microtubes fitted with a metal wedge inside that is pushed forward upon activation of a lever on a stainless steel handle (Figure 7C) that can be attached to the extractors. The open lumen of the extractor is pushed over the exposed instrument head and the fragment is clamped by mechanically locking the instrument in the lumen of the extractor with the elongated metal wedge. The extractor and handle are carefully twisted clockwise and anticlockwise while exerting a pulling action on the file until it is retrieved.

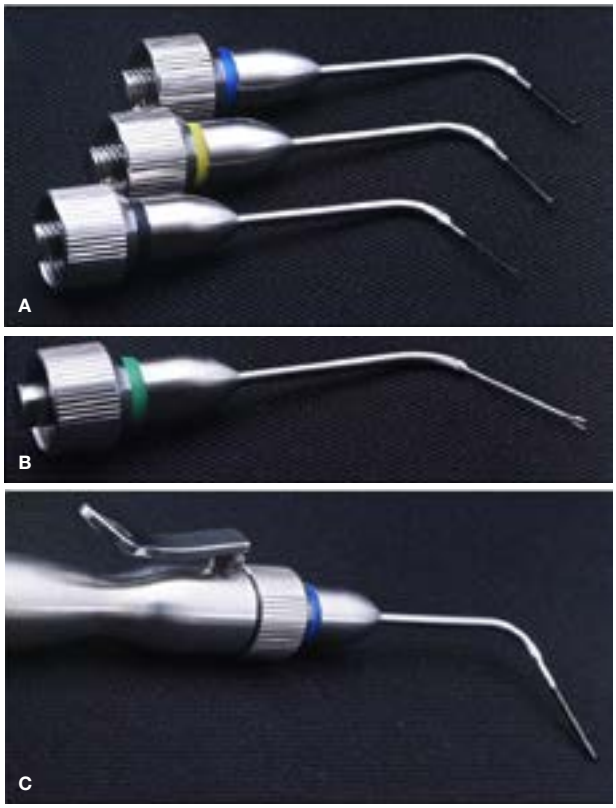

Figure 7.
A. Extractors (0.8, 1.0 and 1.2 mm in diameter).
B. Crab claw-shaped tweezer.
C. The activation handle attached to one of the extractors of the Zumax Broken Instrument Removal Kit (Zumax Medical).

CASE REPORT 4

A 51-year-old female presented with a history of a fractured rotary file in the disto-buccal root canal system of her right maxillary first molar (Figure 8A). The tooth formed the distal abutment of a three-unit bridge extending from the right maxillary first premolar. Upon clinical examination it was noted that the abutment had decemented and it was decided to section the bridge before treatment.

Under high microscope magnification the coronal aspect of the fragment was visible. A no. 3 Start X tip (Dentsply Sirona) (Figure 8B) was used to remove some restrictive dentine before an ultrasonic instrument (Endosonare file mounted in a U-File holder) was used around the coronal aspect of the tooth to create a trough of approximately 1.2 mm (Figure 8C).

The 1 mm trephine was used to remove more dentine around the fractured segment to expose the coronal aspect of the fragment for about 2.5 - 3 mm (Figure 8D). The 1 mm Zumax extractor was pushed over the exposed instrument head and the fragment was secured by mechanically locking the instrument in the lumen of the extractor with the elongated metal wedge (Figure 8E).

The extractor and handle were carefully manipulated until the fragment was retrieved. Figure 8F depicts the result after root canal preparation and obturation of the root canal system.

iii. Terauchi File Retrieval Kit (TFRK)

For the Terauchi File Retrieval Kit (TFRK) it is recommended to use no. 2 and no. 3 GG burs (max 1000 rpm), ensuring minimal removal of the dentine to conserve the surrounding root structure. The canal should be enlarged to at least four sizes (0.2 mm) larger in diameter than the separated file.[37] The no. 3 GG bur has a diameter of 0.9 mm and is the maximum GG bur to use for canal preparation. The use of larger GG burs increases the chances of stripped perforations, especially in curved canals.

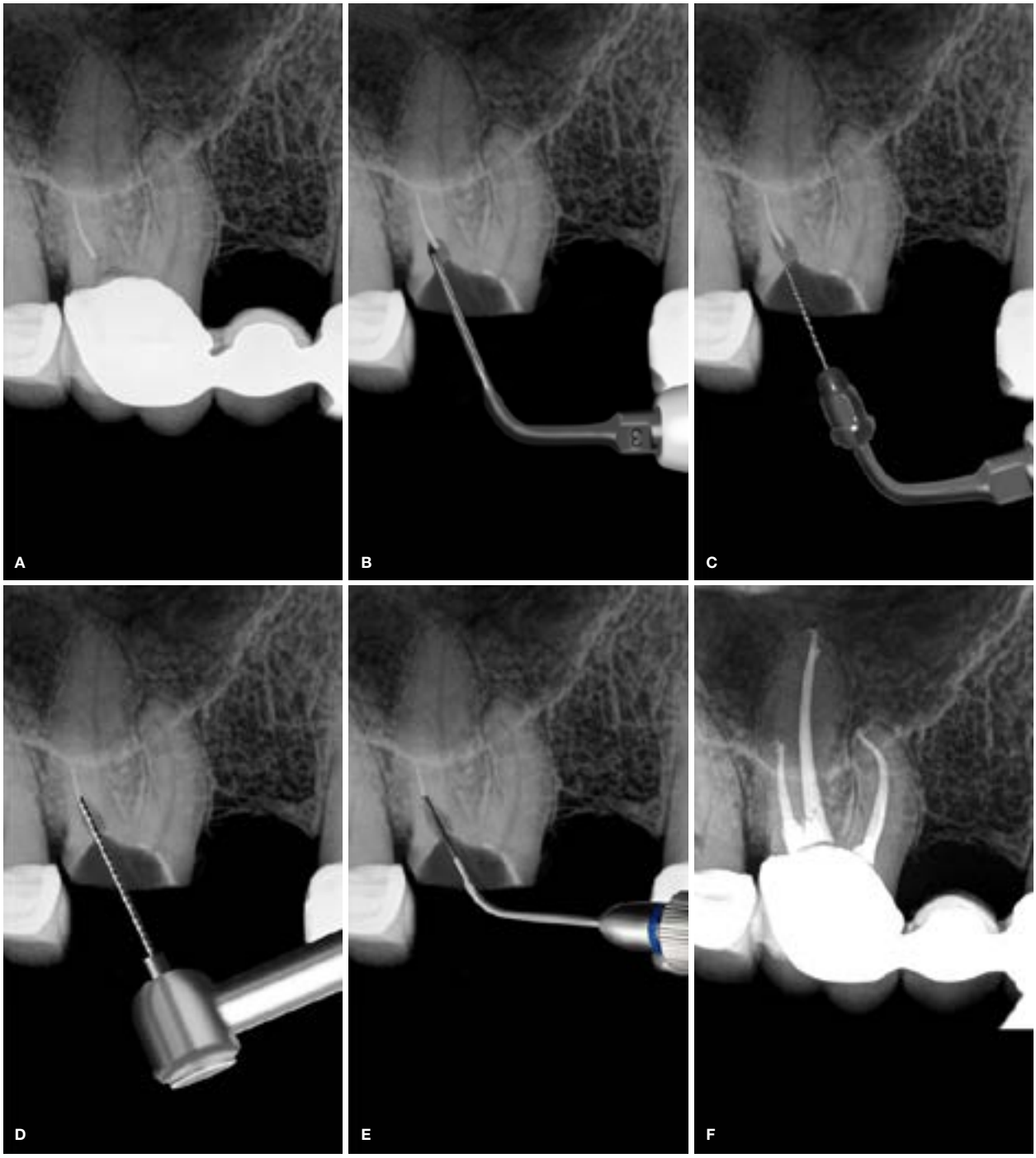

Figure 8.
A. Periapical radiograph of a maxillary left first molar showing a fractured file in the disto-buccal root canal.
B. Removal of restrictive dentine with Start X no. 3 tip.
C. Trough created around the coronal aspect of fractured file with an Endosonare file mounted in a U-File holder.
D. Coronal aspect of fractured instrument exposed with a 1 mm trephine.
E. Extractor placed over head of the fractured file in order to remove it.
F. Postoperative obturation result.

The TFRK Micro-Trephine bur is used at 600 rpm, rotating in a counter-clockwise direction, to remove a small amount of dentine around the coronal aspect of the fractured segment (**Figures 9A and B**). It can also encourage a bound file segment to reverse-thread back coronally and loosen.

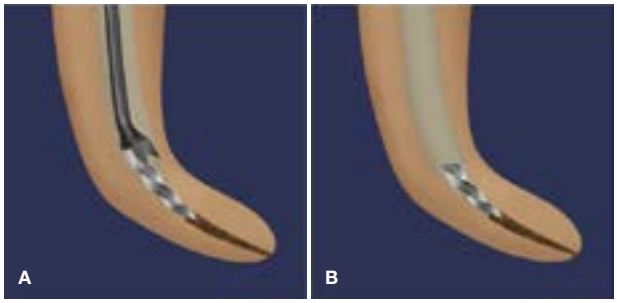

Figure 9. (Adapted from Terauchi, 2012[37])
A. TFRK Micro-Trephine bur is used to remove a small amount of dentine around the coronal aspect of the fractured segment.
B. The coronal aspect of the fractured segment is exposed.

An ultrasonic TFRK spear tip is brought into the canal and then activated on the dentine wall of the inner curvature to create a tiny space of approximately 1.0 mm away from the fractured surface of the file fragment (**Figure 10A**). The spear tips are extremely thin and sharp at the ends; it advisable to use the latch-grip rubber polishing point included in the TFRK to further thin and sharpen the spear tips before and between uses to improve their effectiveness and avoid removal of unnecessary tooth structure.

According to Buchanan[38], it seems logical to trough the canal wall on the outside of its curvature, because that is where the fractured edge will be engaged. The problem is that, according to Terauchi[37], troughing on the outside of the canal curvature does not work because: a) troughing the wall increases the curvature of the canal, while cutting the inside-of-the-curve canal wall straightens the canal, and b) activating the ultrasonic tip on the outside-of-the-curve wall hammers the segment and actually moves it further down the root canal.

After troughing the inner curvature, a shallow groove is cut along the outer curvature (**Figure 10B**) so that no obstruction can keep the fragment from being kicked out coronally by ultrasonic vibration. Finally, two specially designed microspoon tips are used to connect the inner and outer grooves that were created. The two microspoon tips face toward (the 6 o'clock tip) and away from (the 12 o'clock tip) the ultrasonic handpiece and are chosen relative to the direction of the canal curvature.

The root canal is then filled with EDTA solution to enhance the ultrasonic cavitation effect and acoustic streaming for removal. Ultrasonic vibration should be applied to the separated file in the space created between the fragment and the inner curve of the canal and move in "push and pull" motions until it is removed. Most separated files usually come out in 10-30 seconds with ultrasonics (**Figure 10D**). If a separated file shows resistance to disengagement for more than 60 seconds, it is recommended to remove more dentine apically along the inside wall of the fragment before the next removal attempt.

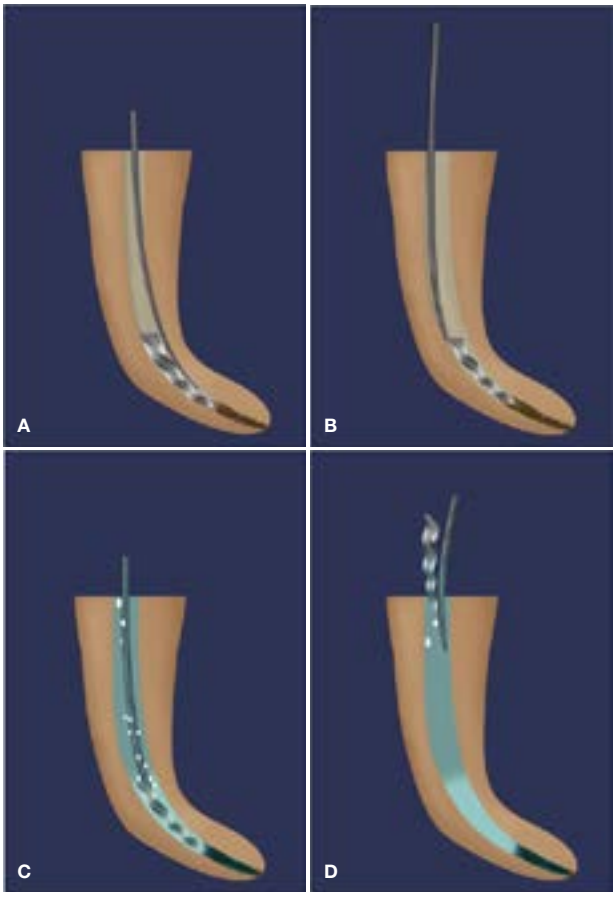

Figure 10. (Adapted from Terauchi, 2012[37])
A. TFRK spear tip is activated on the inner curvature to create a tiny space of approximately 1.0 mm deep from the fractured surface of the file fragment.
B. A shallow groove is cut along the outer curvature.
C. The root canal is then filled with EDTA solution to enhance the ultrasonic cavitation effect and acoustic streaming for removal using the TFRK spear tip.
D. Separated file dislodged from the root canal.

All the ultrasonic tips in the TFRK are made of ductile stainless steel and it is possible to pre-bend them if necessary. The appropriate power setting when using these tips is typically in the lower quarter of the ultrasonic unit's power range and must be activated intermittently by tapping the foot control for one to two seconds, rather than being used in continuous mode. Intermittent activation keeps the tips from overheating and sends a relatively powerful ripple through the long, thin instruments. After two or three pulses, the tips are removed, cooled and cleaned with a wet alcohol sponge, and then replaced for further work until the file is loosened. Working with ultrasonic tips next to fractured file segments in a continuous rather than pulsed activation increases the risk of breaking the file segment into smaller pieces.

Terauchi[37] demonstrates that separated files longer than 4.5 mm in any canal, or those in curved canals greater than 60°, are extremely difficult to retrieve with ultrasonic tips alone. On average, it took longer than nine minutes to remove fragments longer than 4.5 mm, while separated files shorter than 4.5 mm were easy to retrieve with ultrasonics alone and the removal time was about five minutes. He concludes that ultrasonic removal attempts should be performed on a separated file shorter than 4.5 mm long, and ultrasonics in conjunction

with another device, such as the loop device, should be considered if ultrasonic removal time exceeds five minutes.[38,39]

The Yoshi loop in the TFRK is a stainless steel micro-lasso that extends from the end of a stainless steel cannula attached to a handle with a retraction button for tightening the loop around a loosened file segment. If using the loop, the fragment must be loose and exposed peripherally by at least 0.7 mm.

The Yoshi loop is prepared by moving the red retraction button forward to extend the wire lasso. A DG-16 explorer tip is then placed inside the lasso, and the retraction button carefully pulled backwards until the wire loop is felt to tighten on the explorer tine. This rounds the loop, leaving enough space to place it around the end of the file segment.

Before the explorer is removed from the loop, it is rotated back to a position parallel to the cannula to bend the rounded loop to a 45-degree angle. This rounded, angled loop wire is then ideally formed to drop down the root canal (Figure 11A) and around the coronal ex posed end of the file segment (Figure 11B), ideally seen under magnification.

The red retraction button is moved backwards to tighten the loop around the loosened file segment and is carefully tugged in several directions until the file is pulled out of the canal (Figure 11C).

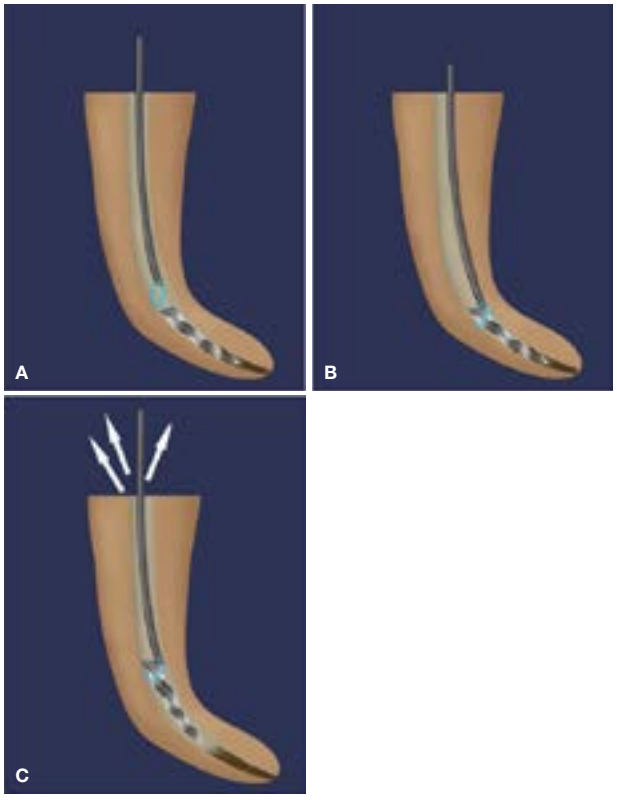

Figure 11. (Adapted from Terauchi, 2012[37])
A. Rounded, angled loop wire on the Yoshi loop dropped down the root canal under magnification
B. Loop wire is placed around the coronal exposed end of the file segment.
C. Retraction button on the handle is moved backwards to tighten the loop around the loosened file segment, before the handle is carefully tugged in several directions until the file is pulled out of the canal.

CASE REPORT 5

The patient, a 41-year-old male, presented with a poor root canal treatment and a fractured instrument in the mesio-buccal root canal of his left mandibular first molar (Figure 12A).

Number 2 and 3 GG burs were used to create a staging platform (Figure 12B) and a TFRK Micro-Trephine bur was used at 600 rpm rotating in a counter-clockwise direction to remove a small amount of dentine around the coronal aspect of the fractured segment (Figure 12C). An ultrasonically driven TFRK spear tip was brought into the canal and then activated on the dentine walls on the mesial and distal (Figure 12D) aspects of the fragment to create a space of approximately 2.5 mm deep from the fractured surface of the file fragment. The two microspoon tips were used to connect the inner and outer grooves created with the TFRK spear tip.

The root canal was filled with EDTA solution and ultrasonic vibration was applied to the separated file in the space created between the fragment and the canal walls. As the file could not be removed after 80 seconds and was more than 4.5mm long, it was decided to use the Yoshi loop (Figure 12E) to retrieve it. Figures 12F and G show, respectively, periapical radiographs of the tooth after file removal and the final obturation result after retreatment of the root canal systems.

iv. EndoCowboy (Köhrer Medical Engineering))

The EndoCowboy (Köhrer Medical Engineering) (Figure 13) is the latest endodontic instrument for removing broken root canal file segments from root canals. The separated instrument is also removed by placing a wire loop projecting from a needle (Figure 14) at the end of the EndoCowboy around the fractured end of the file, after which the loop can be tightened, securing it around the file segment to be removed. This micro-lasso tool can be adjusted precisely and makes it possible to grab files even deep down in the canal with minimally invasive access.

The technique is very similar to the Yoshi loop, but the wire of the lasso is (1) a lot stronger; (2) available in three different thicknesses; and (3) gives the clinician more confidence in removing fractured instruments. The manufacturer recommends a straight-line access to the separated instrument, which must be created with an ISO 70 file or a size 2 GG bur.

The head of the instrument should be exposed by creating a small circular space of at least 1 mm deep with an ultrasonic tip so that the lasso can be placed around the fractured instrument. The fragment can be loosened further with ultrasonics until a “dancing movement” of the fragment is observed. However, the authors have removed several ingrained instruments by exposing only the head before using the high-tear-resistant lasso wire to extract the file.

The EndoCowboy (Köhrer Medical Engineering) is held like a hand piece. After the preformed lasso is placed

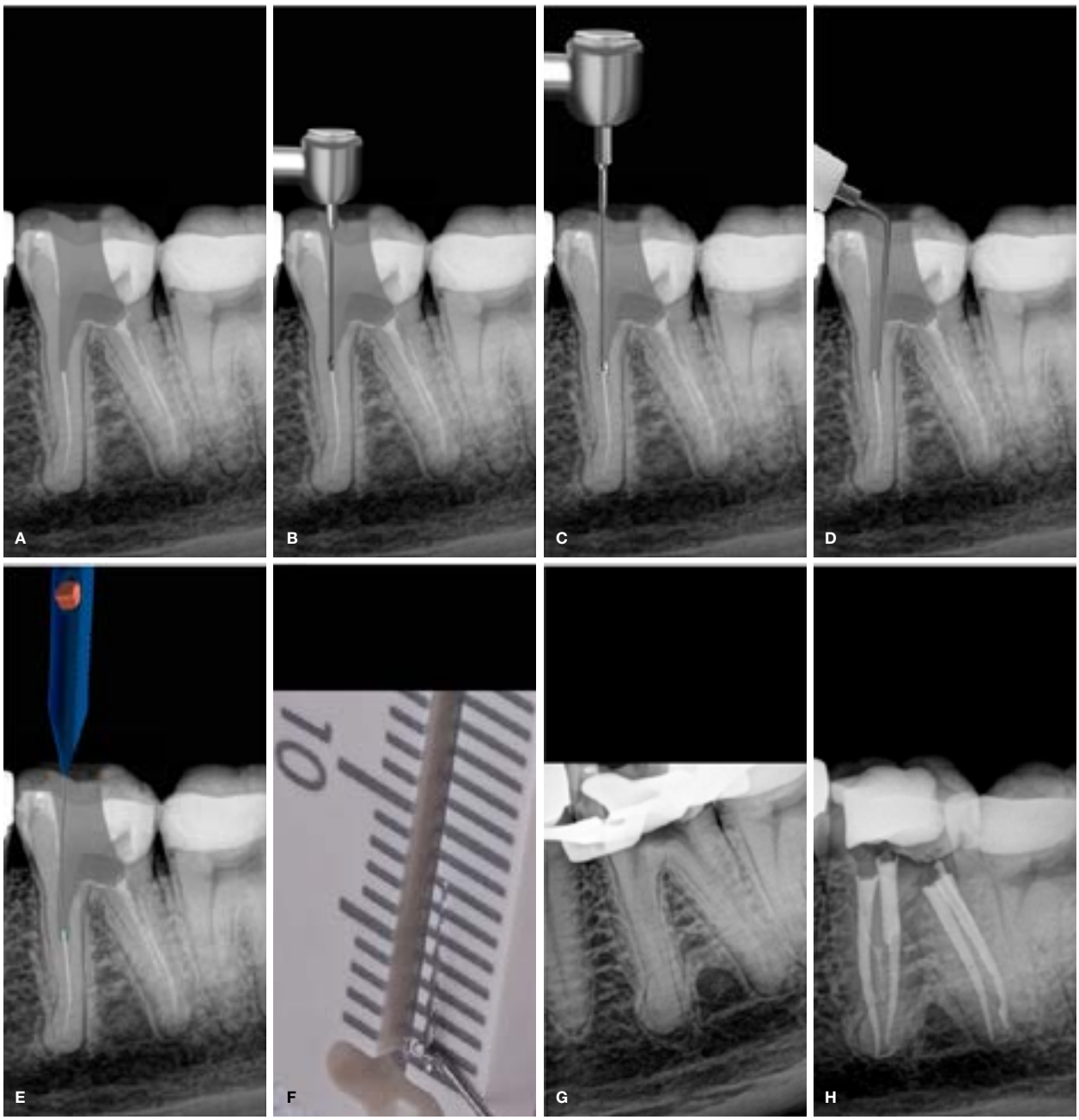

Figure 12.
A. Periapical radiograph of a mandibular left first molar showing a fractured file in the mesio-buccal root.
B. Staging platform created with a modified GG no. 3 and drill.
C. Coronal portion of the fracture file exposed using the TFRK microtrephine bur.
D. Space created around the fractured instrument both mesially and distally with an ultrasonically driven TFRK spear tip and spoon tip.
E. Yoshi loop placed around the exposed head of the fractured file.
F. Extracted fractured fragment measuring 7 mm on a ruler.
G. Periapical radiograph showing successful removal of fractured instrument.
H. Postoperative obturation result.

Figure 13. EndoCowboy (KÖhrer Dental).

Figure 14. Magnified view of the wire loop projecting from a needle cannula.

around the separated instrument, it can be closed by tightening the wire. One of the unique characteristics of the EndoCowboy (Köhrer Medical Engineering) is that the dental assistant can help to operate the device. This person can turn the adjusting wheel clockwise to control the tension of the lasso. This allows the doctor to concentrate fully on placing the lasso around the separated instrument without using any hand movements to close the loop around the instrument.

In order to exert enough tension on the separated instrument, the lasso must be pulled tightly around it. The device is fitted with a special built-in ball bearing that allows precise tightening and maximum tactile feedback of the wire loop tension when the dental assistant adjusts the wheel. Once the required amount of tension is set the lasso will remain in the desired position, enabling the doctor to concentrate on the movement need to extract the file. However, too much tension on the lasso must be avoided, since it can cause the wire to tear. The fractured file is extracted from the root canal using a movement similar to extracting a tooth.

As mentioned before, the EndoCowboy specially drawn stainless steel lasso guarantees maximum tear resistance to enable strong traction. The wires are available in three different thicknesses preloaded in metal cannulas. The thinnest wire is 0.8mm preloaded in a cannula of 0.3mm; a standard 0.1mm wire is loaded in a 0.4mm cannula and a thicker wire of 0.12mm in a 0.5mm cannula.

CASE REPORT 6

A 54-year-old male presented with bite sensitivity and occasional discomfort on his right mandibular first molar (**Figure 16A**). Radiographic examination revealed a poor root canal treatment with a fractured file in the mesio-buccal root canal system and the possibility of a missed root canal system in the distal root.

An access cavity was prepared trough the existing crown and a no. 3 GG bur was used to create a staging platform. A size 15 Endosonare file (Dentsply Sirona) mounted in a U-File holder (Endo Kit E12, NSK) was used to trough around the coronal aspect of the fragment (**Figure 16B**), before a TFRK spear tip was used to create a further space of approximately 1.5mm deep on the dentine wall of the inner curvature from the fractured surface of the file fragment. The EndoCowboy, preloaded with the a standard 0.1mm wire in a 0.4mm cannula, was introduced into the root canal, the preformed lasso was positioned around the separated instrument, and the lasso closed by tightening the wire by turning the adjusting wheel clockwise (**Figure 16C**). The fractured fragment was extracted from the root canal using a pulling action. Figure 16d shows the final obturation result after retreatment of all the root canal systems.

CONCLUSION

Procedural errors, of which instrument fracture is probably the most challenging to manage, can occur during any stage of root canal cleaning and shaping. Instrument fracture is likely to have a negative impact on the long-term prognosis of the tooth. Proper training and clinical experience, together with adherence to sound clinical principles and guidelines for clinical use, can limit the incidence of instrument separation.[40] When faced with a separated endodontic instrument the clinician has the option to bypass it, to leave it *in situ* or to retrieve it.

Removal of fractured instruments is influenced by the length of the instrument, its diameter and position as well as the root canal anatomy and curvature.[41] A study by Wilcox et al.[42] demonstrates that the least possible dentine structure should be sacrificed for file removal attempts, as it has been reported that canal enlargement of 40% to 50% of the root width increases susceptibility to vertical fracture. Suter et al.[7] recommend that attempts to remove fractured instruments from root

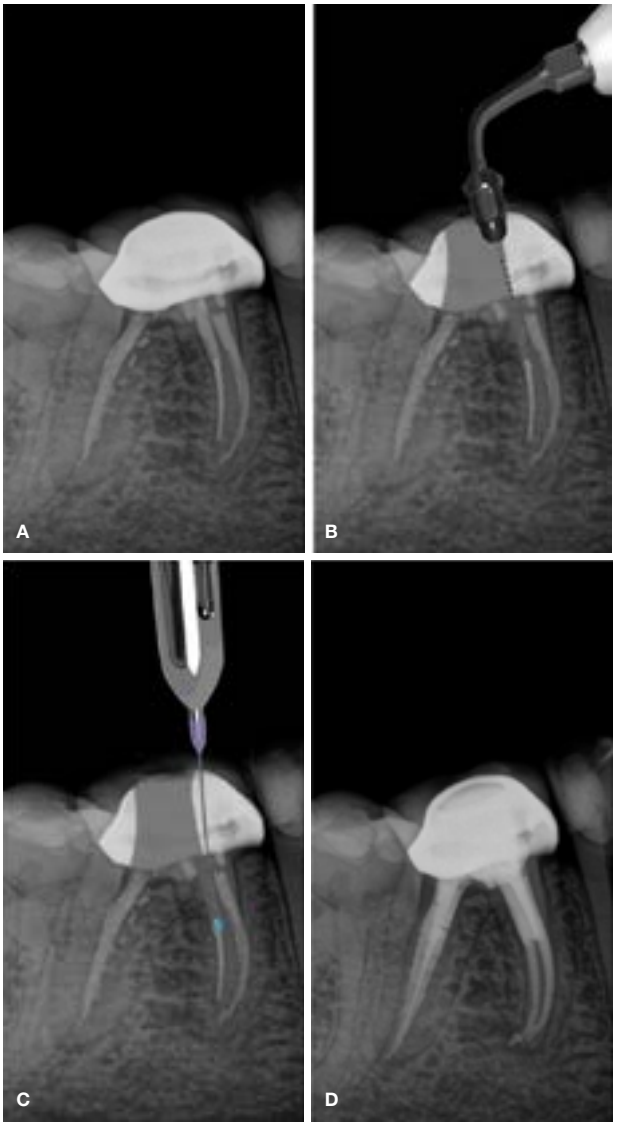

Figure 16.
A. Pre-operative periapical radiograph of a mandibular right first molar with file fracture in the mesio-buccal root canal.
B. A size 15 Endosonare file mounted in a U-File holder to trough around the coronal aspect of the fragment.
C. The EndoCowboy positioned around the separated instrument in order to extract the fragment.
D. Postoperative periapical radiograph after retreatment of all the root canal systems.

canals should not exceed 45 to 60 minutes because of operator fatigue or overenlargement of the root canals. The extended removal time may also lead to iatrogenic errors such as root perforation and vertical root fractures. In this paper the authors illustrate different approaches to the clinical management of endodontic instrument fracture, with specific focus on file retrieval methods and commercially available retrieval systems. The case studies presented should provide the clinician with helpful insights into the clinical management of these often challenging scenarios.

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Re-thinking South African dentists' role in a pandemic

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ABSTRACT

Mass disasters such as terrorism, earthquakes and virus outbreaks challenge any healthcare system. Response teams to disasters typically consist of health professionals, local government, corporations, and community organizations, academics and the scientific community. Dentists or dental hygienists have traditionally only played a role in the identification of victims or in the treatment of facial trauma in disaster response.

In South Africa, the response was mainly driven by medical professionals. Collaborative practice supported by inter-professional education may offer a solution to assist countries struggling with access to healthcare and overburdened health systems. In addition, revisiting the dentists' role in prioritising oral health and its relationship with general health and well-being is much needed. This short article provides a perspective on the role of South African dentists' contribution to health during a pandemic.

Keywords

Pandemic, disaster, collaborative practice, inter-professional education, responders, public health, dental schools, models.

Re-thinking South African dentists' role in a pandemic

Health care workers are at the forefront of any disaster response- man-made or natural. Worldwide there has been an increasing number of natural disasters and terrorist events resulting in a need for a mass casualty response. The Middle East respiratory syndrome (MERS) in 2012, the Ebola outbreak (2014), the Zika virus outbreak (2015) and the current Corona virus challenge healthcare systems.

These events place a huge burden on emergency services locally and nationally. The demands range from emergency medical rescue systems, medical resources, accurate information and a trained workforce. Comprehensive response plans include 'interdisciplinary health professionals, local government, corporations, and community organisations including non-profit organisations, academia and the scientific community'.[1] The Health Professions Council of South Africa published a guidance document to all healthcare practitioners stating that 'practitioners may be required to depart from their established procedures, although this should be done responsibly, reasonably and in the best interest of patients'.[2] Eliav (2017) proposed that the role of dentists extend beyond traditional dentistry by virtue of the education they receive.[3] He also called on dentists to lead collaborative practices to improve the health of the communities. The purpose of this paper is to highlight the need to re-think dentists' contribution to health in South Africa.

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Involvement of dentists in previous disasters

Traditionally first responders usually include doctors, nurses, and emergency medical technicians or paramedics. Morlang first suggested the potential role of an oral health care worker as part of a civilian and military disaster response team in 1996.[4] The 1980 MGM Grand Hotel and Casino fire in Las Vegas, was the earliest report of dental hygienists' role in a mass fatality incident.[5] The dental hygienists assisted in obtaining and verifying post-mortem records and radiographic imaging of the victims.

In 2001, Bacillus anthracis spores were spread through mail in the United States of America (USA). 18 persons were infected and five deaths were reported.[6] The response from patients and dental professionals indicated a need for accurate information about the diagnosis, management and prevention strategies of anthrax infections. It is also highlighted the lack of preparedness in the event of a disaster. The American Dental Association convened a consensus workshop on Dentistry's response to bioterrorism in 2002. Zohn et al. reported that 350 dentists and dental auxiliaries assisted with the forensic identification of victims of the World Trade Centre attacks.[7] Following the seaquake in South East Asia in 2004, 80% of the non-Thai victims were identified by dental information.[8]

In 2006, the scope of practice in dentistry was modified in Illinois, USA.[4] The Illinois Dental Practice Act describes the dental emergency responder (DER) -dentist or dental hygienist- as "acting within the bounds of his or her license when providing care during a declared local, state or national emergency." The DER is 'appropriately certified in emergency medical response, as defined by the Department of Public Health."[4]

In 2007, the American Dental Association resolved to promote dentists' role in a disaster with the following: education and training programmes to help dental volunteers during public health emergencies, protection of dentists' licensing for treatment of public health emergencies across state lines , and credentialing systems affecting oral health care workers interested in supporting a public health response.

In July 2009, the World Health organisation alerted us to the H1N1 pandemic. The Swine Flu or Influenza A flu is an acute respiratory disease of swine origin. The highly contagious virus was transmitted by person to person and droplet spread.[9] The virus spread rapidly and the CDC estimated that between 151,700-575,400 people worldwide died from (H1N1). In May 2009, a group of dental students were infected resulting in the closure of the Harvard School of Dental Medicine.[9] By October 2009, at least four vaccines were available. Due to the occupational risk of exposure, healthcare workers were recommended to be immunised. In the state of Massachusetts, USA, dentists were deputised to administer immunisations.[10]

In 2013, dentists were included into the Pandemic and All-Hazards Preparedness Reauthorization Act (PAHPA). Dentists may now be included as disaster response public health responders. This legislation also allows dental schools to receive funding to train public health and medical response workers.[11]

The role of dental schools in a disaster

Dentists do play an important and effective role in disasters but it has largely been limited to processing missing persons and identifying remains. A survey of deans of medical and dental schools and presidents of medical and dental societies concluded that dentists are not only adept to act as first responders in a mass casualty event but they also have an ethical responsibility to be involved in response to a disaster.[12]

Dental schools have a responsibility to provide accurate information to the students, patients and to the communities they serve. Academics at dental schools are well placed to ensure that oral health care workers are appropriately trained to respond to the disaster. Simultaneously to the ADA 2002 consensus workshop, the New York University College of Dentistry proposed that the dental school curriculum include bioterrorism studies and training and should prepare dentists to respond to a public health disaster.[13] The plan covered all stages of education: predoctoral basic competencies, postdoctoral training competencies, elective continuing education and advanced programmes for interested persons.

Psoter et al. proposed educational objectives for hospital-based dentists to prepare them to contribute to a hospital disaster response.[14] They concluded that many hospital-based dentists already receive an integrated training by medical professionals and they could serve as additional capacity or be redeployed. In the present COVID-19 pandemic, oral surgery residents at Rutgers University volunteered to treat patients at the Emergency room as there was a shortage of medical staff.[15]

Inter-professional collaborative practice

Interprofessional education (IPE) is a learning strategy to accomplish collaborative practice.[16] IPE creates a platform to share knowledge and skills among professions. The World Health Organisation (WHO) defined IPE as 'students from two or more professions who learn about, from and with each other to enable effective collaboration and improve health outcomes'.[17]

Collaborative practice is defined as a dynamic process when "multiple health workers from different professional backgrounds work together with patients, families, carers and communities to deliver the highest quality care".[18] A study of collaborative practises in American dentistry identified three main benefits of collaborative practice:
1. Improved access to healthcare.
2. Reduced costs and increased productivity.
3. Better quality of services.

Collaborative practice allows participants to merge their expertise with others resulting in improved outcomes. Enablers to collaborative practice include: 'organisational mandate, clear sets of responsibilities, a team structure and shared goals and outcomes as well as a supportive environment'.[16]

Dentists are capable of detecting, screening and preventing systemic conditions. There has been mounting evidence of the relationship between oral health and general overall health. For instance, oral health has been linked to an increased risk for cardiovascular disease, diabetes and Alzheimer's disease. In addition, patients taking medications for chronic conditions may suffer from oral conditions as a result. This further illustrates the need for a good collaborative relationship between dentists and medical professionals as it has potential to affect patient outcomes.

In 2015, the Federation Dentaire Internationale (FDI) published its report 'Optimal Oral Health through Inter-Professional Education and Collaborative Practice'.[16] The organisation believes that dentists should lead the process of interprofessional collaboration. Effective relationships with medicine, public health and all other health Practitioners are essential.

The Interprofessional Education Collaborative (IPEC) developed core competencies for interprofessional collaborative practice. These were updated in 2016 and defined as:

Competency 1*: Work with individuals of other professions to maintain a climate of mutual respect and shared values.*

Competency 2: *Use the knowledge of one's own role and those of other professions to appropriately assess and address the health care needs of patients and promote and advance the health of populations.*

Competency 3: *Communicate with patients, families, communities, and professionals in health and other fields in a responsive and responsible manner that supports a team approach to the promotion and maintenance*

of health, and the prevention and treatment of disease.

Competency 4: *Apply relationship-building values and the principles of team dynamics to effectively plan, deliver and evaluate patient/population-centered care, and population health programs and policies that are safe, timely, efficient, effective and equitable.*[19]

The most important outcome of this initiative is to further enable the development of a workforce which will optimise health care and advance population health.

Current practices of IPE in dentistry

A 2012 survey reported IPE opportunities in American dental education at 34% and eventually in 2015 it was recorded at 69%.[19] By 2015, 90% of dental schools in America offered IPE to students and 75% also offered training to dental educators. The American Dental Association Commission on Dental Accreditation for dental education programmes revised standards in 2016 to include a competency on collaborative practice.

A 2020 national survey of American dental schools reported that 96% of the schools engaged in clinical and non-clinical inter-professional sessions.[20] The development, implementation and early results of an IPE curriculum at a dental school was reported on in 2020.[21] In this model, dental students were placed at a community health care facility and they had the opportunity to perform head and neck examinations as well as intra oral checks. This was shared with medical students and other allied care students.

Patients were also referred for further oral care. Similarly, medical students rotated in dental emergency and treatment planning clinics allowing them to share their knowledge about systemic conditions.[21] While there were challenges and the impact on patient outcomes are not clear at this stage, this example of IPE could have important lessons for dental education especially in areas where access to healthcare is problematic.

Locally, Filies reported 'that there are no South African studies currently in the literature that provide evidence of IPE core competency development in curriculum design'.[22] Filies advocates the scaffolding of competencies along the continuum of learning and appropriately aligned assessments.[22]

In South Africa, there is a paucity of literature around IPE and dental education although it has been identified as a competency by the HPCSA. Moodley and Singh conducted research around the opportunities for interprofessional collaboration for dental therapy and oral hygiene students at the University of the KwaZulu Natal.[23] They suggest that ideal opportunities would be involvement in community-based disease prevention and health promotion interventions.

Proposed roles for dentists in a pandemic

During a bioterrorist attack, pandemic or disaster, local health services and hospitals may be overwhelmed or damaged rendering them ineffective. Worldwide, healthcare workers account for 10% of global COVID-19 infections.[24] While in South Africa, Health Minister Zweli Mkhize reported that 'more than 24 000 health-care workers have been infected with Covid-19, while another 181 have succumbed to the virus'.[25] The current Coronavirus pandemic provides a background for collaborative practice.

In South Africa, the White paper and Act on Disaster Management define the roles of Local Authorities as well as Provincial and National government in disaster management. The HPCSA may register medical practitioners or dentists as volunteer services to participate in health care relief activities under supervision temporarily. In addition, some healthcare professionals such as oral hygienists in independent practice in South Africa are required to have a Level three First aid qualification but this does not include dentists.

Dentists in South Africa may contribute to the health services during a disaster in the following manner:

Prior to an attack:

Biologic weapons may be classified as bacterial agents, viral agents and biological toxins. Traditionally, dentists would not be familiar with the effect they may have on the human body. Education programmes for all oral health care workers and the public on the pathogens used in bioterrorism and the oral manifestations of such a disease would be essential. [6]

- All dentists should be required to maintain a Level 3 First aid qualification.
- Expose dentists and dental students to disaster medicine.
- The local dental association should develop up-to-date quick reference guides for distribution. These guides should provide dentists with necessary information to respond appropriately.[6]
- Dentists should be included in an integrated community response plan.[6]
- Dental surgeries are ideally located within communities which could serve as stockpiling sites for materials and supplies.[6]
- Dentists should form part of a network of healthcare practitioners in their area of practise.

During an attack:

Dental surgeries contain sterilisation equipment, air and gas lines, suction equipment, radiographic equipment, instruments and needles. If local hospitals or clinics are overwhelmed these facilities could be used as mini-hospitals.[6]

Surveillance and notification: Dentists as community clinicians are often well placed to detect characteristic oral and cutaneous lesions and report it to the health authorities. Unusual patient and employee attendance patterns may be the warning signs in a community of impending threats.[0]

Diagnosis and monitoring: Dentists may collect salivary and nasal swabs for the diagnosis of such an attack.[6]

Referral: Dentists are able to refer patients which require further management or who need specialist treatment.[6]

Immunisations: Organisations may expand their workforce capacity by recruiting health care workers to assist. If rapid vaccination of the population is required, dentists may be recruited to assist in the immunisation programme.[6]

Medications: Dentists could be asked to assist in dispensing of preventive medication or the prescription and dispensing of medications to the public. Additionally, they may be used to repackage medications for dispensing. Dentists are also capable of monitoring patients for adverse events or side effects to medication.[6]

Triage: During a disaster response, the health system may become overburdened with casualties. In this instance, it is essential that patients are triaged correctly so that priorities for treatment may be established. Dentists with the appropriate training may assist in this process.[6]

Medical care augmentation: Dentists or dental specialists may have the training to provide the following services:

- Starting intravenous lines.
- Performing appropriate surgery and surgery.
- Shock management.
- Stabilising patients.
- Collecting blood samples.
- Taking medical histories.
- Providing cardiopulmonary resuscitation.[6]

In the case of a pandemic, the establishment of a quarantined area or the infection of large numbers of medical personnel may limit the services available to a community. Dentists may be recruited to provided primary health care if they have not been affected.[6]

Decontamination and infection control: Dentists and dental assistants are knowledgeable in infection control and decontamination. They are a valuable asset to assist medical personnel and to educate the community.[6]

Oral and facial health care: Facial injuries are common trauma injuries in earthquakes. Thus dentists and oral and maxillofacial surgeons play an important part of the team.26 Patients experiencing pain or signs of infection may need to seek dental treatment. It is important that emergency dental treatment be made available with appropriate measures in place to protect patient and health care workers.

Currently, the Corona virus pandemic is an infectious respiratory disease which may result in the aspiration of oral bacteria into the respiratory tissues. Recent evidence confirms the relationship between oral bacteria and pneumonia.[27] It also confirms that oral health and oral hygiene habits may affect the incidence and outcomes of patients with pneumonia.

After the attack: Dentists trained in forensic odontology may assist response teams. They may also continue to monitor and provide local surveillance.[6]

Recommendations for the future

The onset of the Corona pandemic has challenged many academic institutions worldwide. Dental schools have been particularly affected as the risk for the dental profession is very high with the performance of aerosol generating procedures. This has resulted in the closure of many dental clinics restricting dental care to emergencies only. Dentists' response to a pandemic or disaster could positively impact patient outcomes if the profession is able to leverage its contribution to overall health. Investing in interprofessional education models for health professions in South Africa could address issues of shortage of healthcare personnel and accessibility to healthcare.

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Do the CPD questionnaire on page 591

The Continuous Professional Development (CPD) section provides for twenty general questions and five ethics questions. The section provides members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure continuing education. The importance of continuing professional development should not be underestimated, it is a career-long obligation for practicing professionals.

Online CPD in 6 Easy Steps

1 Go to the SADA website www.sada.co.za.
2 Log into the 'member only' section with your unique SADA username and password.
3 Select the CPD navigation tab.
4 Select the questionnaire that you wish to complete.
5 Enter your multiple choice answers. Please note that you have two attempts to obtain at least 70%.
6 View and print your CPD certificate.

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What's new for the clinician?
- Excerpts from and summaries of recently published papers

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Compiled and edited by V Yengopal

1. The effects of a hydrogen peroxide mouthrinse on the intraoral viral load of SARS-CoV-2

MJ Gottsauner, I Michaelides, B Schmidt, et al. A prospective clinical pilot study on the effects of a hydrogen peroxide mouthrinse on the intraoral viral load of SARS-CoV-2. Clinical oral investigations. 2020; 2 Sep: 1-7.

INTRODUCTION

The most common biological complication around dental implants is peri-implant mucositis, which can be found in about 64.6% of all implant patients.[1] Peri-implant mucositis is defined as an inflammation of the peri-implant soft tissues with Bleeding on Probing (BOP), without loss of supporting bone, with or without increased Probing Depth (PD) and with visual signs of inflammation.[1]

Untreated peri-implant mucositis can progress to peri-implantitis with progressive soft tissue and bone loss. The use of homecare measures such as brushing, mouthrinsing, the use of oral irrigators, etc. have all been used to maintain good oral hygiene and reduce plaque load. Bunk and colleagues (2020)[1] reported on a trial that sought to determine whether the adjuvant use of an oral irrigation device with chlorhexidine (CHX) as part of self-administered plaque control significantly reduces severity and presence of peri-implant mucositis compared to no irrigation or irrigation with water.

MATERIALS AND METHODS

The was a prospective clinical study investigating the effects of a mouthrinse with 1% hydrogen peroxide on the intraoral viral load of hospitalized SARS-CoV-2-positive patients in an isolation ward.

Only patients with a positive test for SARS-CoV-2 within the last 72 h were included in this study. Exclusion criteria were indication for intubation or mechanical ventilation and severe stomatitis.

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Patients were screened for eligibility by one medical doctor and provided with detailed description of the study outline which involved the following procedure: patients were asked to gargle their mouth and throat with 20 mL 0.9% NaCl for 30 s for acquiring a baseline oropharyngeal specimen for the SARS-CoV-2 real-time PCR (RT-PCR) test. Immediately afterwards, patients had to perform a mouthrinse with 20 mL 1% hydrogen peroxide by gargling their mouth and throat for 30 s. Thirty minutes after this mouthrinse, another oropharyngeal specimen for the SARS-CoV-2 RT-PCR test was acquired by letting the patients gargle their mouth and throat with 20 mL 0.9% NaCl for 30 s. The respective quantities of copies/mL of SARS-CoV-2 RNA were analyzed by RT-PCR.

SARS-CoV-2 was isolated from the oropharyngeal specimens that exhibited more than 103 copies/mL of SARS-CoV-2 RNA at baseline by using kidney epithelial cells from African green monkey (Vero-CCL19 cells, ATCC). Data are reported as median values (with 1st and 3rd quartiles) and were statistically analyzed non-parametrically using the Wilcoxon signed-rank test for related samples on a significance level of $\alpha = 0.05$.

RESULTS

Twelve SARS-CoV-2-positive patients were included in this study. These 12 patients (6 female and 6 male) had a median age of 55 years (range: 22–81 years). One patient was hospitalized in an intensive care unit (without need of intubation), and 11 were hospitalized in an isolation ward. Eleven out of the 12 patients showed comorbidities (e.g., diseases of the liver, cardiovascular system or kidney, haematological diseases, and obesity).

In two out of the 12 initially included patients, no SARS-CoV-2 RNA could be detected in the baseline specimens prior to performing the 1% hydrogen peroxide mouth-

rinse. Therefore, these two patients were excluded from the study. There were no significant differences between baseline viral load and viral load 30 min after the 1% hydrogen peroxide mouthrinse ($p = 0.96$).

CONCLUSIONS

The researchers concluded that a 1% hydrogen peroxide mouthrinse does not reduce the intraoral viral load in SARS-CoV-2-positive subjects.

Implications of practice

The recommendation of a preprocedural mouthrinse with hydrogen peroxide before intraoral procedures is questionable and thus should not be supported any longer, but strict infection prevention regimens remain crucial for patient safety.

Reference

1. Gottsauner MJ, Michaelides I, Schmidt B, et al. A prospective clinical pilot study on the effects of a hydrogen peroxide mouthrinse on the intraoral viral load of SARS-CoV-2. Clinical oral investigations. 2020; Sep 2: 1-7.

2. The effect of adjuvant oral irrigation on self-administered oral care in the management of peri-implant mucositis.

D Bunk, M Eisenburger, S Häckl, et al. The effect of adjuvant oral irrigation on self-administered oral care in the management of peri-implant mucositis: A randomized controlled clinical trial. Clinical Oral Implants Research. 2020 Oct.

INTRODUCTION

The most common biological complication around dental implants is peri-implant mucositis, which can be found in about 64.6% of all implant patients.[1] Peri-implant mucositis is defined as an inflammation of the peri-implant soft tissues with Bleeding on Probing (BOP), without loss of supporting bone, with or without increased Probing Depth (PD) and with visual signs of inflammation.[1] Untreated peri-implant mucositis can progress to peri-implantitis with progressive soft tissue and bone loss.

The use of homecare measures such as brushing, mouthrinsing, the use of oral irrigators, etc. have all been used to maintain good oral hygiene and reduce plaque load. Bunk and colleagues (2020)[1] reported on a trial that sought to determine whether the adjuvant use of an oral irrigation device with chlorhexidine (CHX) as part of self-administered plaque control significantly reduces severity and presence of peri-implant mucositis compared to no irrigation or irrigation with water.

MATERIALS AND METHODS

This was a randomized controlled clinical trial that consisted of adult participants suffering from peri-implant mucositis who were recruited during regular oral maintenance and treatment appointments at an implant dental clinic. Study participants met the following inclusion criteria: (**a**) presence of at least one dental implant in function for >12 months; (**b**) clinical diagnosis of peri-implant mucositis at one or more implant sites with (bleeding on probing) BOP with or without suppuration; (**c**) absence of radiographic bone loss when compared to previous radiographs; (**d**) visual signs of inflammation (mGI ≠ 0) at one or more implant sites.

Exclusion criteria were: (**a**) Peri-implantitis, which was either diagnosed with progressive bone loss comparing previous and current radiographs, or in case of missing previous data or radiographs, with bone levels ≥3mm apical of the most coronal portion of the intraosseous part of the implant; (**b**) smoking or chewing tobacco, alcohol- or drug addiction; (**c**) systemic diseases or conditions such as metabolic bone- and haematological diseases, immunodeficiency, uncontrolled diabetes mellitus, kidney failure, risk of endocarditis, tumour or radiation in head and neck area; (**d**) systemic antibiotics use 3 months prior to baseline, steroid and coumarin therapy 3 months prior to baseline; and (**e**) physical limitations that prevent adequate oral hygiene technique.

At baseline, clinical measurements were carried out and all subjects were given a standardized basic oral hygiene instruction in verbal and written form. The basic oral hygiene instructions contained a description of the recommended brushing technique and cleaning of removable dentures where applicable. After this sequence, the patients were instructed to brush again with a small amount of fluoride-containing toothpaste. The written oral hygiene instruction additionally contained instructions for interproximal cleaning. The patients were given additional information about the consequences of progression of peri-implant mucositis and transition into peri-implantitis. A sub- and supramucosal mechanical debridement with titanium curettes and polishing using a rubber cup and low abrasive polishing paste were performed at baseline.

Patients assigned to group 1 did not receive any additional instruction or demonstration and were advised to follow the basic oral hygiene instructions independently at home. Patients assigned to group 2 and 3 were given a demonstration and written instructions for the use of an oral irrigation system (Waterpik®). Patients of group 2 received bottles with in total 4.5 L of water and patients

of group 3 received bottles with in total 4.5 litres of 0.06% Chlorhexidine solution. Patients of group 2 and 3 were instructed to use the oral irrigator 1x/day with 50ml of the respective solution after toothbrushing and interproximal cleaning in the evenings at the implant. Toothbrushes and fluoride-containing toothpaste were handed out to all subjects at baseline visit.

All patients returned for follow-up examination and data collection after 4, 8, and 12 weeks. The follow-up visits included measurement of clinical data and a standardized protocol for reinstruction and remotivation. Patients in group 2 and 3 also received additional quantities of the assigned irrigation solution.

Only one implant per individual was included in the study. If more than one implant per patient was diagnosed with peri-implant mucositis, the implant with the highest mucositis severity score was chosen for the study. Clinical data were measured at four sites around the implant (mesio-buccal, disto-buccal, mesio-lingual, disto-lingual).

The following clinical parameters were assessed: (a) PD in mm with a standard probe; (b) Bleeding on Probing (BOP); (c) Modified Gingival Index for dental implants (mGI); (d) Modified Plaque Index for dental implants (mPI); (e) mucositis severity score. The mucositis severity score reaches from 0-16. It is calculated based on the sum of the mGI-score from 4 implant sites (maximum 12 points – as the mGI reaches from 0–3) and the BOP-positive sites (maximum 4 points, if BOP is present on all 4 examined implant sites. All parameters were measured in each patient at each appointment.

RESULTS

A total of 72 patients were assessed for eligibility for inclusion into this trial. Twelve patients did not meet the inclusion criteria and were excluded: six patients were smokers, four patients suffered from peri-implantitis, two patients had a risk of endocarditis. At baseline examination, no significant differences among the groups were observed for age, sex, implant region, dentures, mucositis severity score, and PDs.

At the 12-weeks follow-up, the prevalence of peri-implant mucositis of all examined implants was 30%. The lowest prevalence of peri-implant mucositis was found in group 3 with 5%, followed by group 2 (35%) and group 1 (50%).

Patients of group 3 showed significantly lower BOP-positive sites after 12 weeks when compared to control group (–0.75 [95% CI –1.26; –0.25], $p = .004$). No significantly lower BOP-positive sites could be found when oral irrigation with CHX was compared to water (–0.36 [95% CI –0.86; 0.14], $p = .16$), or when water irrigation was compared to control group (–0.39 [95% CI –0.9; 0.11], $p = .12$).

Groups 2 and 3 showed a considerably higher reduction of mucositis severity score after 12 weeks compared to control group. The final examination showed a mean mucositis severity score of mild inflammation for groups 2 and 3 and moderate inflammation in group 1.

The severity of peri-implant mucositis, based on the mucositis severity score after 12 weeks, varied significantly between the groups. The linear regression analysis showed a significant improvement of the severity of peri-implant mucositis when using CHX irrigation compared to oral hygiene instructions only (–2.4 [95% CI –4.19; –0.61], $p = .001$). The use of an irrigation device with water compared to control resulted in an estimated drop of 1.7 points in mucositis severity score after 12 weeks closely to the significance threshold (–1.7 [95% CI –3.49; 0.1], $p = .06$), however, but was not significant.

The highest mean decrease of average mPI from baseline to final examination was observed in group 1; however, the scores of group 2 and 3 were very close to that. The results of the linear regression for mPI showed no significant influence of the three interventions ($p = .99$) on the outcome. Except for mPI, each regression model showed superiority of the use of an oral irrigator with CHX compared to control group.

The hypothesis, that the adjuvant use of CHX in an oral irrigation device significantly reduces clinical signs of peri-implant mucositis compared to no oral irrigation or water irrigation was confirmed.

CONCLUSIONS

The researchers concluded that the adjuvant use of an oral irrigator with 0.06% CHX in addition to mechanical biofilm removal can reduce severity and presence of peri-implant mucositis after 12 weeks.

Implications for practice

The use of CHX instead of water as oral irrigator solution seems to offer significantly better clinical outcomes in patients with peri-implant mucositis. However, the possible long-term effect of CHX use must be noted by clinicians.

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Below are pictures of two cases of infection of the jaws that could be life-threatening within a few days due to spread of bacteria into perioral fascial spaces. Discuss the clinical and radiological features and what is your provisional diagnosis?


Fig. 1


Fig. 2

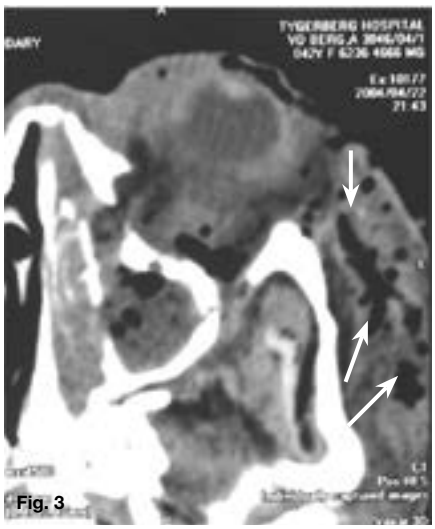
Fig. 3

INTERPRETATION

Figure 1, is an example of an overwhelming oral infection, extending on to and destroying part of the face, and fatal if inadequately treated. It has been described as a 'severe scourge to mankind' as children are mainly affected. It also known as Cancrum Oris or Noma. It is a rapidly spreading gangrene of the oral and facial tissues that occurs usually in debilitated or nutritionally deficient persons. It occurs chiefly in persons that are undernourished or debilitated from infections such as diphtheria, dysentery, measles, pneumonia, scarlet fever, syphilis, tuberculosis and blood dyscrasias, including anemia. Thus Noma may be considered a secondary complication of a systemic disease rather than a primary disease. Noma appears to originate as a specific infection by Vincent's organisms, an acute necrotizing gigivostomatitis, which is soon complicated by secondary invasion of many other microbial forms, including streptococci, staphylococci and diphtheria bacilli. Figure 1 also shows gross destruction and sloughing of the facial tissues as a result of spread of the infection from the maxillary and mandibular gingivae. Noma was common among starving prisoners in Nazi concentration camps, particularly children in the 1940s and invariably fatal. Later, attention was drawn to the disease in Africa in the 1960's. Otherwise, noma has virtually disappeared from developed countries, and for decades the disease has been largely ignored. Figure's 2 & 3 is a patient who presented after extraction of the 26 and 27 with proptosis and orbital cellulitis of the left eye. Axial CT reveals a large soft tissue mass extending into the ethmoid sinus, maxillary sinus and orbit and various collections of gas (arrows) is also discernible. A diagnosis of necrotizing fasciitis (NF) of the orbit was made which is a rare and deadly condition that requires prompt surgical and medical management to decrease morbidity and mortality. The term necrotizing fasciitis was coined by Wilson in the 1950s to describe necrosis of the fascia and subcutaneous tissue with relative sparing of the underlying muscle. Necrotizing fasciitis is characterized by rapid destruction of tissue, systemic toxicity, and, if not treated aggressively, gross morbidity and mortality. Early diagnosis and aggressive surgical treatment reduces risk; however, it is often difficult to diagnose Necrotic fasciitis, and sometimes patients are treated for simple cellulitis until they rapidly deteriorate. Necrotizing fasciitis is a rapidly progressive disease of the subcutaneous tissue that carries a high mortality within hours to days without prompt medical and surgical interventions. Fasciitis of the orbit is particularly concerning because of lasting morbidity of the eye even after successful treatment of the fulminant systemic toxicity. The causative organism of NF is usually polymicrobial but streptococci and enterococci are the most common isolates. The major determinant of survival is the time from admission to the operating room for debridement. The patient's left eye had to be removed. Without treatment NF is a rapidly progressive condition and can result in significant morbidity. Management of this condition includes both medical treatment and surgical debridement. Early intervention is of vital importance to save the patient's life as septicaemia often leads to death within 24-96 hours.

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Dental images
- Their use and abuse

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INTRODUCTION

Patients' exposure to medical and dental radiographic examination has increased over the years,[1] with dental X-ray procedures now accounting for almost one-third of all radiographic examinations.[2] Although they only contribute 2-4% towards the collective effective dose of exposure, all efforts should be made to minimize the amount taken and to keep exposure as low as diagnostically achievable.[2]

When considering radiographic examinations, the potential diagnostic or therapeutic benefits to the individual or society need to be weighed up against the possible risks that the exposure may cause, taking into account the "efficacy, and benefits and risks of alternative techniques that have the same objectives but involve no or less radiation".[2,3]

To this end the acronym ALARA was coined to stress that all diagnostic radiographs should aim to keep doses as low as reasonably achievable without compromising the diagnosis.[1] With the advent of digital imaging there has been a trade-off between image quality and reduced radiation dosage. As such the term has been altered to ALADA, as low as diagnostically acceptable, to reflect this compromise.[2]

Literature review

The best approach to reduce radiation exposure is to follow a strict protocol of justification (considering benefits versus risks), optimization (selection of the best type of radiographic examination) and limitation (implementing radiation protection and minimising exposure).[2]

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This can be achieved in three ways. Firstly, by physically minimising dosage through equipment factors.[4] However, clinicians who try reduce dosage by altering machine settings must be aware that radiographs obtained with very low dose exposure settings that have no diagnostic value due to poor image quality cannot be justified or ethically condoned.[2]

Secondly they should apply appropriate selection criteria when deciding if radiographic examination is needed.[4] The routine practice of taking a panoramic radiograph (PR) or full mouth periapical images (PA) for all new patients is not justified, and any radiographs taken should be based on the patient history, clinical examination including a study of previously taken radiographs (if available, recent and of good quality),[2,3] consideration of all alternative non-radiographic options,[2] and the determined need.[4] Thereafter, radiographs should only be taken if they will make a "substantial contribution to distinguishing between treatment options" and/or will provide additional information which could change the diagnosis and management.[2]

Thirdly they should have established quality assurance programmes to ensure that all radiographs taken are of high quality and diagnostic value in order to avoid the need for repeated exposure.[4] By basing radiographic selection on this strategy of clinical evaluation in asymptomatic patients and selected radiographic imaging in symptomatic patients has resulted in a 43% reduction in the number of radiographs taken with no corresponding clinical increase in undiagnosed disease.[3]

Special attention should be paid to minimize radiation exposure in vulnerable patients such as children and pregnant patients. Factors that should influence the decision to perform a radiograph should include: patient age, economic indicators, the patient's vulnerability to known risk factors and the medico-legal consequences if disease is undetected and untreated.

Informed consent is needed from all patients prior to exposing them to any radiation procedure. They need to be alerted as to the potential hazards, and where possible X-ray free examination techniques should rather be used during the decision making process. If radiographs are taken, then the dose and diagnosis must be recorded in the record files. This is both a legal requirements and will help avoid extra exposure from repeat examinations. Any clinician who takes a radiograph must be competent and trained in its evaluation and interpretation. This necessitates they have a working

knowledge of anatomy and pathology, and the ability to detect non-significant artefacts. Where CBCT scans are used they must also be able to identify and interpret 3D structures. In addition, they need to ensure that they analyse the entire field of capture and not just the areas of interest.**[2]

Kühnisch et al. (2019) and Beneyto et al. (2007) proposed guidelines and clinical indicators for taking radiographs which have been summarised below.[2,4]

Bitewing (BW) radiographs

It has been suggested that as the caries prevalence has declined in many industrialised countries, so too has the need for BW radiographs. They are still often indicated for children and adolescent patients in order to detect proximal caries in enamel and dentine, occlusal carious lesions, to classify and monitor caries extension, to detect secondary caries, to evaluate the quality of dental restorations, and to assess interproximal bone levels.[2] Patients with a high caries risk profile may need more frequent monitoring by means of follow up BW radiographs, at individually determined time intervals.

They are not recommended for detecting bone loss associated with periodontitis,[2] but may be used for patients with uniform pockets less than 6mm, or irregular shallow pocketing.[4]

Periapical (PA) radiographs

These are suitable for assessing dental anatomy (root canal morphology, root development, apical areas), and dental pathology (periapical lesions, furcal involvement, dental trauma, and various forms of tooth resorption). They may be used in several clinical situations such as:

- In patients with symptomless, vital teeth with deep carious lesions and / or teeth with symptoms of reversible pulpitis where endodontics or extractions may be needed.[2]
- In symptomatic and / or non-vital teeth with deep carious lesions or other pathoses where the BW is not able to capture the root sufficiently, and to establish the feasibility of endodontic treatment.[2]
- Following dental trauma to detect root fractures and tooth developmental stages (in children).[2]
- In teeth with anatomical malformations or developmental disorders.[2]
- In cases of suspected supernumerary teeth, impactions or retained deciduous teeth.[2]

They are essential for all aspects of endodontics including preoperative views to determine pulp and root canal anatomy and length, working length estimation, during mechanical treatment, and post-operatively to assess the success of the obturation.[4] They are also mandatory for any surgical root canal treatment.

They are only indicated prior to extracting teeth if there is a history of difficult extractions, where there is a suspicion of complex root anatomy, prior to orthodontic extractions, for lone standing maxillary molars, for teeth with associated swelling, in impacted or partially erupted teeth, for roots that may be lying close to important anatomical structures, and in patients with medical histories that will place them at risk if complications occur.[4]

They may be used in patients with more advanced periodontitis or with suspected periodontal/endodontic lesions.[4]

Panoramic radiographs (PR)

Routine use of PR as a screening tool is unjustified, as studies have found that over 65% of these images had no relevance to the subsequent treatment.[4] They are also not needed in edentulous patients who present with no clinical signs and symptoms unless implant therapy is planned.[4] In which case a CBCT is the more appropriate modality to use.[4]

They are not suited for initial caries detection or cases of mild acute dental infections.[3] In more severe cases they can help to view the extent of decay, presence of associated infection, and to decide if the teeth are saveable. They may also be easier to take in situations where there is associated extra/intra oral sepsis, pain and swelling.[2]

They are indicated for dental conditions affecting larger areas of the jaws or situations where a patient cannot tolerate the intra-oral device needed for a BW or PA radiograph. However in the latter situation there will be the trade off in image quality and possible ghost images associated with PR radiographs.[2]

They are essential in cases of trauma to assess jaw and joint fractures. However, PA images are still better for detecting dental fractures,[2,4] and other views may also be better suited to assessing high condylar fractures.[4]

They may be used to assess the full mouth and jaws in patients who have generalized dental anomalies or congenital defects.[2]

They may be indicated in situations where PA radiographs suggest possible bone pathology, in order to view a wider field and to help diagnose the condition.[2]

They may be used to evaluate impacted third molars prior to planned extraction as they can provide information about tooth position, relationship to the maxillary sinuses (maxilla) and inferior alveolar nerve canal and lower border (mandible). Erupted third molars can usually be assessed with PA radiographs. (Note previous radiographs may reveal that there are no opposing third - molars present and negate the need for any radiographs in patients with suspected impactions).[4]

They may be used in certain orthodontics cases to show the state of the dentition, and presence or absence of underlying teeth, but are not always necessary as part of routine treatment.[4]

They may be used in patients with advanced periodontitis and heavily restored dentitions as an alternative to taking many PA images. They are also good for monitor-

ing the rate of disease progression in these patients. However they may not show as fine detail as the latter and supplementary PA may still be needed.[4]

Although they are often used as an initial screening tool in patients with TMJ symptoms, studies have shown that they provided little information to influence the diagnosis or subsequent treatment.[4] This may be because a high number of these patients were suffering from myofacial pain/dysfunction or internal disc derangement, and are better diagnosed with magnetic resonance imaging (MRI).[4]

PR can reveal calcifications of the carotid artery by examining the area 1.5 to 2.5 cm posterior and inferior to the angle of the mandible. However they should not be taken for this purpose alone, but rather note that all routine PR should be evaluated for this condition.[3] If suspected or found the patient should be referred to a physician for further management.[3]

Cone-beam computed tomography (CBCT)

CBCT is used to provide detailed cross sectional images of the teeth and surrounding tissues. The field of view (FOV) varies according to the equipment and machine settings and needs to be chosen according to the area of interest in order to keep the exposure dose as low as possible.[2]

CBCT is seldom indicated in children, not used for caries detection, or to detect acute dental infections (unless the aetiology cannot be established with any of the other methods). They are seldom used to identify dental or dento alveolar trauma, except in cases such as where the palatal root of a maxillary molar needs to be more closely examined, but one must be aware that the image quality may be distorted by restorative or root filling materials.[2] Some clinicians have advocated their use for detecting the extent of lesions associated with invasive cervical resorption.[2]

They may be helpful to establish the location of teeth with eruption disturbances, especially maxillary canines, as well as any other unerupted impacted or ectopic teeth.[2]

They are suited and in fact recommended in all patients where osseiontegrated implant therapy is planned. They allow for accurate assessment of bone quality and quantity, help in the choice of implant type, length and diameter, aid in planning implant location, as well as for fabricating surgical guides and manufacturing immediate/provisional restorative prostheses.[2]

**NOTE: If a CBCT scan is taken, the onus is on the clinician to ensure they are interpreted and reported on by competent trained professionals. Additionally they have a duty to evaluate the entire FOV and not only comment on the areas of interest. Failure to do so may hold them liable for clinical negligence.[2]

Having established guidelines and indications for the use of dental radiographs, two clinically related ethico-legal issues arise.

1. Patients where radiographs were taken and not needed for the diagnosis and treatment.

2. Patients where treatment was carried out without the requisite or appropriate radiographs having been taken, or where images were not adequately assessed and interpreted, where an excessive number of images were taken, where an unsuitable view was selected for the specific condition, where images revealed crucial information that was not detected, or where any radiographic errors/omissions resulted in compromised and/or unsuited management.

The following three cases illustrate cases of correct radiation use as well as radiation abuse.

CASE 1 - Justified use of diagnostic aids (Figures 1 to 4)

The patient was referred for a panoramic radiograph due to pain affecting the mandible. The dentist detected a radiolucent lesion associated with the mesial root and a loss of lamina dura of the distal root of tooth 47.

This prompted him to perform vitality tests in which both the 46 and 47 tested vital. In addition, no carious lesions were seen clinically or radiograpically on either tooth. It was thus justified to refer for additional imaging. A small field of view CBCT was exposed to limit the area and radiation dosage.

Three dimensional reconstruction of the image data showed destruction of the buccal cortical plate in relation to the 47. The axial and coronal CBCT images confirmed the destruction of the buccal cortical plate. The lesion appeared radiolucent and had a resultant change of the normal internal trabecular structures. Once again further investigation was warranted, and a bioposy was taken. The histolopatgological evaluation confirmed the lesion to be an osteosarcoma, which was subsequently managed.

Had the dentist not been vigilant during the intial examination of the panoramic radiograph this serious, condition may have remained undetected, with potentially fatal consequences.

CASE 2 - Unjustified radiographic exposure (Figure 5)

A 4 yr. old patient referred for a panoramic radiograph. The radiograph was not justified as all interproximal surfaces could have been examined visually, and with minimal discomfort to the child, by careful probing.

CASE 3 - Unjustified exposure where a panoramic radiograph was taken but not examined or interpreted correctly prior to carrying out a full mouth rehabilitation (Figure 6-10).

The patient presented for a routine dental examination complaining of generalised toothache, and missing anterior teeth (12 and 13). A panoramic radiograph was taken as well as numerous “before” (and after) photographs showing a heavily restored dentition (Figures 6, 7 and 8).

Figure 1. Panoramic radiograph.

Figure 2. Three dimensional reconstruction of the image data showing destruction of the buccal cortical plate in relation with tooth 47.

Figure 3 and 4. Axial and coronal CBCT images showing destruction of the buccal cortical plate

The dentist, an "expert and trainer in CAD/CAM technology" informed her that many of her fillings were failing and should be replaced. He also indicated that numerous other teeth needed to be restored. He suggested that all of her restorations be replaced with "white crowns", as well as full coverage crowns on many of her remaining teeth to create a "perfect smile".

The teeth were all prepared, scanned and restored the same day with CAD/CAM fabricated full coverage crowns, and a 4-unit bridge from the 14 to the 11. In total she was provided with 10 crowns and a 4-unit bridge in the maxilla and 7 crowns in the mandible (In total, 17 crowns, one of which was implant supported, and 2 pontics). At the same visit the scaling and polishing was done to remove calculus and staining of the mandibular anterior teeth. The total cost of treatment exceeded R400 000.00 (2018 rates).

She experienced generalised ongoing sensitivity after completion of the work, which her dentist reassured her would dissipate. However, after a few months of constant pain, and sensitivity she sought a second opinion.

Dentist 2 requested her pre-treatment records from her original dentist and was provided with a number of intra oral pre and post-operative photographs, and a PR radiograph. There were no PA views available to

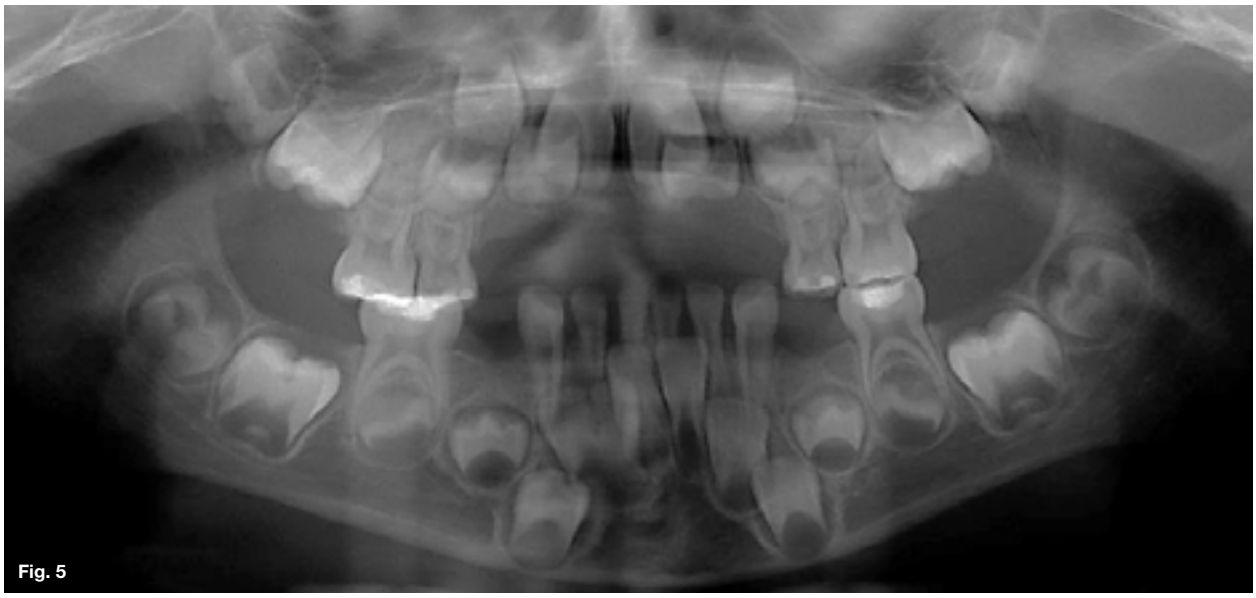

Figure 5. A panoramic radiograph of a 4-year-old child.

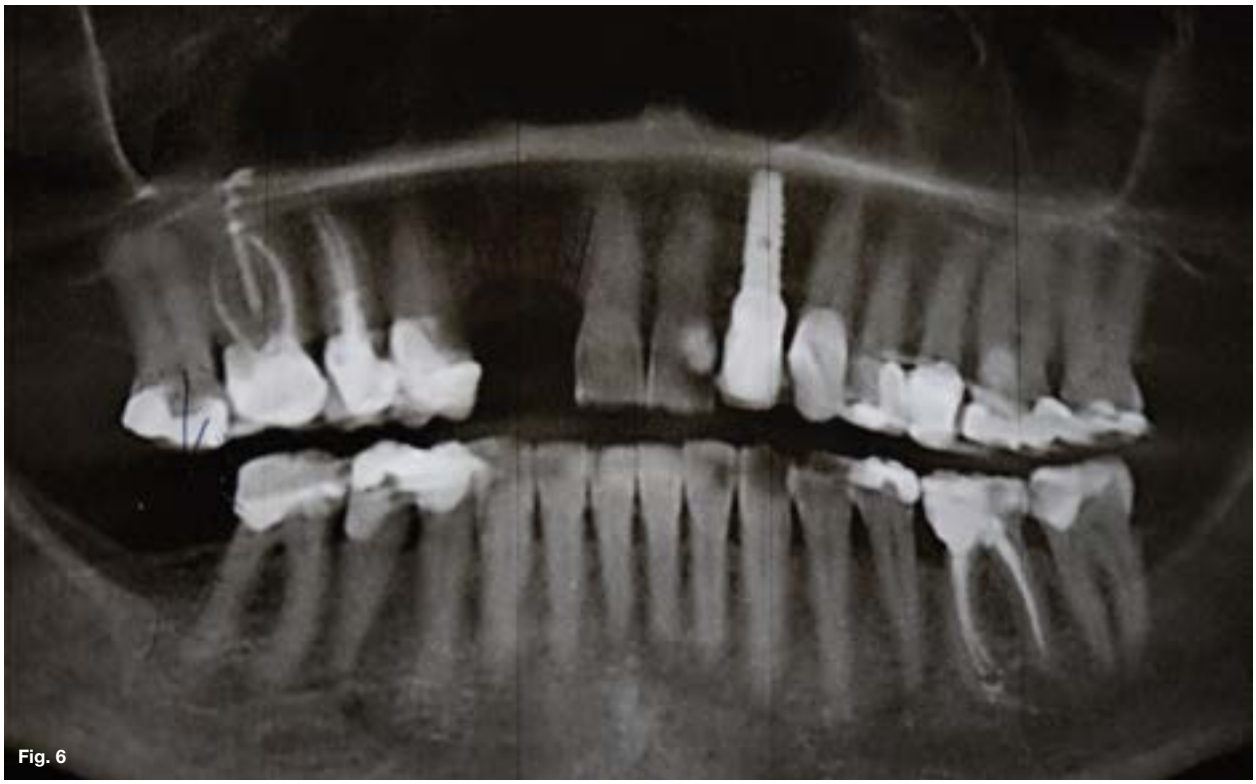

Figure 6. Pre-treatment panoramic radiograph.

Figure 7. Pre-treatment occlusal view of maxillary arch.

Figure 8. Pre-treatment occlusal view of mandibular arch.

Figure 9. Post-treatment occlusal view of maxillary arch.

Figure 10. Post-treatment occlusal view of mandibular arch.

Figure 11. Post treatment rehabilitation.

indicate that there had been a tooth-by-tooth analysis. He examined this data closely. A detailed analysis of the panoramic radiograph revealed the following: generalized moderate to severe bone loss, particularly in the posterior segments with furcation involvement of the 36 and 46. There was also extruded root filling material and a periapical radiolucency on the 16.

Teeth 17, 16, 26, 37, 36, 45 and 46 were all considered to be in need of a periodontal assessment, diagnosis and treatment before any fixed restorative work was done in order arrest the bone loss, and restore her mouth to health. Large and/or faulty restorations with deep subgingival margins were noted on the 16, 15, 25, 26, 27, 36, 45 and 46.

The need for replacing these would have to be confirmed with a clinical evaluation and PA radiographs. She was also in need of a 4-unit bridge spanning from 14 to 11. Many of these teeth may not have needed treatment or could potentially have been restored with small restorations. Thus the treatment plan should have consisted of initial periodontal therapy, extraction of unsaveable teeth (36 and 46), crowns on selected teeth, a 4-unit bridge and minor restorative work. Dentist 2 also took a follow up panoramic radiograph which confirmed that the patient had never received the requisite periodontal therapy prior to this extensive rehabilitation (Figure 12).

This case is a clear example of radiographic abuse, gross over servicing and arguable malpractice. Not only were restorations placed on teeth that were unquestionably in need of periodontal treatment, but also on teeth with minor carious lesions.

She had in effect been provided with an extensive rehabilitation, yet there was no record of any occlusal analysis having been performed prior to cutting the teeth, nor any consideration of placing her in provisional restorations for a time in order to monitor and evaluate the new vertical dimensions, occlusal scheme, aesthetics and speech and masticatory functions.

Figure 12. Post treatment panoramic radiograph revealing persistent periodontally compromised dentition.

DISCUSSION

Diagnostic aids may take the form of photographs, study models, radiographs, clinical observations and measurements, microbial tests, or pathologic/histological investigations. They are an extremely useful, and often crucial part of the initial patient examination and treatment planning appointment. However, their value depends on the correct choice, evaluation, interpretation, diagnosis, and subsequent implementation of management and treatment procedures. Radiographs are one of the most widely used diagnostic aids in dentistry due to their ability to reveal structures and conditions that are impossible to visualise or detect clinically. However, they carry associated financial costs and patient risk factors. Taking incorrect views, exposing patients to unnecessary or excessive amounts of X-rays, repeating procedures when not needed, or failure to examine and interpret the radiographs correctly is not only unethical but borders on negligence and malpractice.

CONCLUSION

The cases presented in this paper illustrate three situations where panoramic radiographs were taken. In the first, the dentist carried out a detailed and meticulous radiographic evaluation, and was astute enough to request further diagnostic procedures, using the correct modality (sectional CBCT). This revealed a potential life threatening condition and resulted in early and appropriate patient management. In the second case, it was unjustified to expose a young patient to this radiation when a clinical examination would have sufficed. In the third situation, not only did the dentist expose and charge the patient for the radiographs, but the subsequent treatment was carried out with no consideration of the dental conditions revealed in the radiograph. This resulted in gross over servicing with unsuitable treatment that could be considered medical malpractice. If a clinician does not have the expertise to analyse a particular image then they should not make use of that modality. However, this option could be detrimental to the patient's welfare. The more responsible and professional approach would be to develop themselves by acquiring training in this field, or alternatively consulting with colleagues who have the requisite skills and expertise.

"You see only what you look for, you recognise only what you know" - Dr Yvette Solomons

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CPD questionnaire

This edition is accredited for a total of 3 CEUs: 1 ethical plus 2 general CEUs

GENERAL

A base-line study of the wear of burs used for chairside milling of ceramic crowns of different hardness - Effect on internal fit and surface roughness

1. Choose the CORRECT answer.
   When milling a ceramic restoration the smallest bur diameter is currently:
   A. 0.5 mm
   B. 1.0 mm
   C. 1.5 mm
   D. 1.25 mm

2. Choose the CORRECT answer.
   The creation of a luting space in a crown is:
   A. to compensate for the milling
   B. to allow for the luting cement
   C. to prevent the crown binding on the preparation
   D. to reduce the thickness of the material

3. Choose the CORRECT statement.
   Diamond milling burs wear according to:
   A. the size of the bur
   B. the number of particles in the bur
   C. the hardness of the material being milled
   D. the density of the material being milled

4. Choose the CORRECT statement.
   As diamond burs used for milling ceramic crowns wear, they:
   A. decrease the internal fit of the crown
   B. affect the marginal gap of the crown
   C. increase the surface roughness of the crown
   D. increase the luting space of the crown

Epidemiological profile of patients utilizing dental public health services in the eThekwini and uMgungundlovu districts, KwaZulu-Natal province, South Africa

5. Choose the CORRECT answer.
   The sample size of this study was:
   A. 5998
   B. 4000
   C. 5600
   D. 1500

6. Choose the CORRECT answer.
   The overall prevalence of dental caries found in KZN for this study was:
   A. 66.4 %
   B. 11.7%
   C. 7.3%
   D. 8.7%

7. Choose the CORRECT answer.
   The overall prevalence of tooth loss found in KZN for this study was:
   A. 8.7%
   B. 5.9%
   C. 6.3%
   D. 7.3%

Giant cell lichenoid stomatitis - An oral medicine case book

8. Choose the CORRECT answer.
   Common sites of oral lichenoid lesions (OLLs) include:
   A. Buccal mucosa
   B. Palate
   C. Lateral border of tongue
   D. Only A and C are correct
   E. Only A and B are correct

9. Choose the CORRECT answer.
   Lichenoid granulomatous stomatitis is characterised by the following histological features:
   A. Lichenoid inflammation with basal cell degeneration and apoptotic bodies
   B. Varying degrees of granulomatous inflammation
   C. Lymphoid follicles with a perineural distribution
   D. All of the above

Fracture of endodontic instruments - Part 1: Literature review on factors that influence instrument breakage

10. Choose the CORRECT answer.
    Cyclic fatigue occurs as a result of which one of the following
    A. Tension-compression stress cycles at the point of maximum flexure
    B. When part of the instrument binds to the canal while the shank continues to rotate
    C. All of the above
    D. None of the above

11. Choose the CORRECT answer.
    Which of the following factors have been implicated in the fracture of endodontic instruments?
    A. Root canal anatomy
    B. Operator experience
    C. Number of uses
    D. All of the above

12. Choose the CORRECT statement.
    The majority of instrument fractures occur in:
    A. the coronal third of the root canal
    B. the middle third of the root canal
    C. the apical third of the root canal
    D. all of the above mentioned locations equally

Modern considerations when approaching fractured endodontic instruments – Part 2: A review of the literature and clinical techniques

13. Choose the CORRECT answer.
    The following factor(s) must be considered once a clinician is confronted with a fractured instrument:
    A. Root canal complexity
    B. Access to materials, instruments and devices
    C. Adequate experience
    D. Location of the fractured instrument
    E. All of the above

14. Choose the CORRECT answer.
    The following medical condition is more suited for attempting fractured file removal rather than extractions:
    A. Bleeding disorders
    B. HIV
    C. Diabetes
    D. High blood pressure
    E. None of the above

15. Choose the CORRECT answer.
    Incorporating a fractured file into the final obturation can be considered in cases where the anatomy is:
    A. very simple
    B. very complex
    C. a single canal
    D. two canals joining
    E. None of the above

Re-thinking South African dentists' role in a pandemic

16. Choose the CORRECT answer. Benefits of collaborative practice in dentistry include:
    A. improved access to healthcare
    B. reduced costs and increased productivity
    C. better quality of services
    D. All of the above
    E. None of the above

17. Choose the CORRECT answer.
    Dentists or dental specialists may have the training to provide the following services:
    A. Starting intravenous lines
    B. Performing appropriate surgery and surgery
    C. Shock management
    D. All of the above
    E. None of the above

18. Choose the CORRECT answer.
    Interprofessional education (IPE) may be defined as:
    A. A learning strategy to accomplish collaborative practice
    B. When two or three professions have the same degree
    C. An assessment strategy to evaluation professional behaviour
    D. None of the above

Clinical Window: What's new for the clinician?

19. Choose the CORRECT statement.
    In the Gottsauner et al study, 2 of the 12 SARS-CoV-2-positive patients were excluded because:
    A. they died during the study
    B. they did not adhere to the protocols
    C. they were moved into the ICU ward
    D. no SARS-CoV-2 RNA could be detected in their baseline specimens

20. Choose the CORRECT answer. BOP showed significant improvements in the Bunk et al. trial. Which statement reflects the findings of the authors?:
    A. Group 3 showed significantly lower BOP-positive sites after 12 weeks when compared to the control group (Group 1)
    B. Group 3 showed significantly lower BOP-positive sites after 12 weeks when compared to Group 2
    C. Group 2 showed significantly lower BOP-positive sites after 12 weeks when compared to Group 1
    D. Group 3 showed significantly lower BOP-positive sites after 12 weeks when compared to Group 2 and Group 1

ETHICS

Dental images - Their use and abuse

21. Choose the CORRECT answer.
    The following unethical conduct was mentioned in this paper:
    A. Performing a clinical examination on a nervous child|
    B. Taking a CBCT scan of a vital tooth
    C. Taking a panoramic radiograph and a CBCT scan on the same visit
    D. Adjusting the machine setting to allow for more images to be taken

22. Choose the CORRECT answer.
    Radiographs should only be taken:
    A. if their benefits outweigh the risks
    B. if the patient consents to this procedure
    C. if exposure is kept to a minimum
    D. All of the above are correct
    E. Only A and C above are correct

23. Choose the CORRECT answer.
    Exposing patients to unnecessary radiation may be considered:
    A. abuse
    B. malpractice
    C. maleficent
    D. All of the above
    E. Only A and C above are correct

24. Choose the CORRECT answer.
Adjusting an X-ray machine to lower dose settings:
A. is a good way to allow the dentist to take more radiographs
B. is acceptable in minor lesions where high definition is not needed
C. is a good idea when taking radiographs in pregnant women
D. All of the above are correct
E. None of the above are correct

25. Choose the CORRECT answer.
The initial treating dentist in the third case scenario acted unprofessionally by:
A. failing to examine the panoramic radiograph adequately
B. failing to take additional PA radiographs of all the teeth to be crowned
C. failing to formulate a comprehensive treatment plan prior to commencing treatment
D. All of the above

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