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Beaked plague doctor mask

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Paul Fürst, engraving, c. 1721, of a plague doctor of Marseilles (introduced as 'Dr Beaky of Rome'). His nose-case is filled with herbal material to keep off the plague.

Medical mask-wearing has a long history dating back to the popular beaded masks worn by doctors in the 17th century during the plague epidemic. They believed that the disease spread through miasmas - bad smells that wafted through the air. Their clothing was thus intended to protect them from these airborne diseases. The original "beak doctor" costume was believed to have been invented by the French doctor Charles de Lorme in 1619 who advocated doctors and surgeons wear a full head-to-toe protective garment. It consisted of an ankle-length overcoat, boots, a wide rimmed hat (that indicated their profession), and a bird-like beak mask. The mask had glass openings for the eyes and a curved beak shaped like a bird's beak with straps that held it in front of the doctor's nose.

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Our Front Cover for this Issue…

The theme for the Front Cover of the South African Dental Journal this year showcases various types of masks. Masks have been admired and worn throughout the world for centuries and play an integral part of many activities including customary rituals, cultural events, battles, entertainment, and for protection. The cover for March features an engraving by Paul Fürst of a plague doctor of Marseilles wearing a beaked mask. Read more on page 57.

Beaked plague doctor mask
Paul Fürst, engraving, c. 1721, of a plague doctor of Marseilles (introduced as 'Dr Beaky of Rome'). His nose-case is filled with herbal material to keep off the plague.

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E-Doc CC,
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Mr René Smulders

GENERAL AND ADVERTISING ENQUIRIES

Mr René Smulders
Email: rene@edoc.co.za

Design and Layout

Ms Reine Combrinck
Email: production@edoc.com

Website smalls advertising / CPD Enquiries and Member contact detail update

South African Dental Association
Tel: +27 (0)11 484 5288
Email: info@sada.co.za

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“Join together - the wolf only snatches the stray bird that flies away from the flock”

SADJ March 2021, Vol. 76 No. 2 p57

NH Wood

Plague doctor outfit from Germany (17th century).
Image source: Juan Antonio Ruiz Rivas, CC BY-SA 3.0

Medical mask-wearing has a long history dating back to the popular beaded masks worn by doctors in the 17th century during the plague epidemic. They believed that the disease spread through miasmas - bad smells that wafted through the air. Their clothing was thus intended to protect them from these airborne diseases.

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It consisted of an ankle-length overcoat, boots, a wide rimmed hat (that indicated their profession), and a bird-like beak mask. The mask had glass openings for the eyes and a curved beak shaped like a bird's beak with straps that held it in front of the doctor's nose.

The beak had two small nose holes which acted like a type of respirator, and was filled with sweet or strong smelling aromatic items. These included dried flowers, herbs, camphor, or a vinegar-soaked sponge. Doctors believed the herbs would ward off the odours that spread the plague, and prevent them from becoming infected.

In addition, they used wooden canes to point out areas needing attention and to examine patients without touching them. The canes were also used to keep people away, to remove clothing from plague victims without having to touch them, and to take a patient's pulse!

In the early 1900's, prior to the influenza epidemic, only surgeons and nurses wore masks when they were treating contagious patients. However, during the flu epidemic, cities around the world passed mandatory masking orders. This practice was embraced by the American public as “an emblem of public spiritedness and discipline.”

Today we are once again facing a global pandemic that has seen the resurgence of mandatory mask wearing as well as the use of hand sanitisers, and social distancing. We now need to all “flock together” and adhere to these measures, known as 'the new normal' if we are to survive and thrive.

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Paul Fürst, engraving, c. 1721, of a plague doctor of Marseilles (introduced as 'Dr Beaky of Rome'). His nose-case is filled with herbal material to keep off the plague.

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

Quality management in oral health care

SADJ March 2021, Vol. 76 No. 2 p58

NH Wood
Managing Editor of the SADJ

Modern dentistry relies on the delivery of care through an evidence-based approach. But what if the evidence is poor, or lacking? In the different clinical contexts of dentistry there is a struggle with a lack of parameters to define quality assurance and quality control, and it becomes the duty of the practitioner to deliver a high standard of care that meet their own levels of acceptability which is governed by personal ethics, laws, policies and principles.

The evidence used in such a scenario is largely empirical. The importance of this is further highlighted by increasing costs and demand for oral healthcare that drives innovation towards efficacy and quality of care.[1]

The question therefore arises: How do we define quality management within our own reference frame? Unfortunately, there is a paucity of literature to provide information regarding the application of quality management in the dental setting as the available material almost always refers to medical practices.

However, by adopting a standardized approach to quality management a practice will ensure continuous improvement in quality of care. Goetz and co-workers define quality assurance as "the systematic measurement and monitoring of process, structure and outcome of care and results in a continuous improvement process".[2]

In resource poorer settings with higher patient demands and pressure, an innovative quality management programme becomes indispensable. However, it is often the case that dentists in such situations do not have access to resources to facilitate implementation of quality management programmes.

One such example is seen in the rotation of community service dentist through oral healthcare facilities without having the opportunity to make any meaningful contribution other than service delivery that sees to the immediate clinical needs of patients. This is in stark contrast to the private practitioner who is an owner and driver of their own practice and arguably, a stronger personal motivation and financial incentive.

Practices that actively implement quality management programs tend to perform better to their counterparts who do not.[2] In clinical practice we have to seek to continually measure what works and what does not, and then implement changes to progressively improve on the outcome being measured. The implementation of quality management systems can comprise of a number of factors to be measured to quantify the provision of care.

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

In light of the limited quality measurement specifications, as well as the lack of measurement standardization it is time to consider the development of an industry standard for quality management policies. These should be flexible, but reliable and valid to fit the different clinical settings in oral healthcare.

In order to continue to provide optimal care and benefits, we have a responsibility to manage our own quality and implement quality assurance measures in practice. This should encompass organizational activities, patient care and service, and even resource management. In this way we will grow the profession and develop standards of care and practice that will be quantifiable and useful measures of outcomes to be used as industry reference standards.

We present the March issue of the 2021 SADJ and trust that you will receive benefit from the content. We thank all the contributors.

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Understanding ICD-10 coding and its usage

SADJ March 2021, Vol. 76 No. 2 p59 - p60

T Parbhoo
Head Clinical Support Services, SADA

In this article, I would like to share with you the below information as compiled and shared by Dr Tinesha Parbhoo, our Head of Clinical Support Services.

While January has come to a swift end, it is our hope that you all have settled in to 2021 and are working with determination and gusto, albeit in unprecedented circumstances. Since joining SADA as Head of Clinical Support, it has indeed been a busy yet fulfilling start to the year.

I am extremely excited to have become part of the SADA team and look forward to assisting you with your coding and other queries. With experience in both private and public oral health and having previously been a practice owner as well as an employee of a dental group, I can identify with the many challenges that practitioners face on a day-to-day basis.

I am determined to guide you when the situation calls for it and am committed to fight on your behalf and champion for the dentist. I therefore encourage you to reach out to me if the need arises and urge you not to feel shy or embarrassed - I am here to help.

- Dr Parbhoo.

Since the start of the year, the Clinical Support Department has received numerous queries on incorrect usage of ICD-10 coding, both from third party funders rejecting accounts and from members. As such, we found it imperative to clarify basic ground rules with regards to ICD-10 codes. Members are reminded that ICD10 are diagnostic codes and while we frequently receive calls to supply you with the ICD10 codes for procedures, this is not always possible as we at the office have not physically examined your patients to make a diagnosis.

According to the WHO, the International Classification of Diseases (ICD) is the "foundation for the identification of health trends and statistics globally, and the international standard for reporting diseases and health conditions. It is the diagnostic classification standard for all clinical and research purposes. ICD defines the universe of diseases, disorders, injuries and other related health conditions, listed in a comprehensive, hierarchical fashion".

The purpose of ICD-10 is to translate diagnoses of diseases and other health problems from descriptions into

an alphanumeric code, which permits easy storage, retrieval and analysis of the data. It also allows for the establishment of a systematic recording, analysis, interpretation and comparison of morbidity and mortality data collected within the country but also with other countries.

The **minimum** basic code in the ICD system is a **primary code**: this consists of an alphabetic letter followed by 2 numbers e.g., K00.

The primary code indicates:
- The body system that the condition relates to e.g., the digestive system;
- Which section of that body system is affected by the condition e.g., teeth, jaws, salivary glands.

Secondary codes are codes that further describe the patient's condition or the cause of the patient encounter e.g., K01.1 (impacted teeth).

Other dentally significant codes include:

- **Z-codes**, which represent factors influencing health status and contact with health services i.e., reasons for encounters e.g., a dental examination (Z01.2)

- **S-codes**, which indicate injury, poisoning and certain other consequences of external causes. All S-codes must have 5 characters except for S03.2, which is a competent 4-character code. Any fracture code must be described with a fifth character of 0 (closed fracture) or 1 (open fracture). The default use for a tooth fracture, which cannot really be described as open or closed, is 1.

- **T-codes**, which demonstrate the effect of a foreign body entering through an orifice.

Tinesha Parbhoo: Head Clinical Support Services
Email: clinical@sada.co.za

The South African standard stipulates that **all S and T codes must be accompanied by the External Cause Codes (ECC)**. ECCs allow for the classification of environmental events, circumstances and conditions as the cause of injury, poisoning and other adverse effects.

They begin with the letters V (transport accidents), W (falls and exposure to inanimate objects), X and Y (exposure to other incidents such as complications of medical and surgical care.) All ECCs must also be 5-character codes, describing how and where the incident occurred.

The primary code and ECC are always separated by a forward slash.

When coding for a certain procedure, it is helpful to remember that the ICD-10 codes for a procedure must be the same as that reflecting the **reason** for the procedure i.e., "What diagnosis led to the treatment being performed?" The ICD-10 code should hence reflect the cause of the condition rather than the procedure itself.

This applies for all procedure codes billed during that procedure. Let us look at a few examples from queries received:

- *I need an ICD-10 code for a radiograph. We always used Z01.2, but the medical aid says it's not correct. We must do a root canal treatment and I can't seem to find anything on the internet.*

In this case, the ICD-10 code for the radiographs will be the same as the reason for the procedure i.e., K04.0 (pulpitis). Note: Not to be confused with radiographs taken during a general examination, which will attract the code Z01.2.

- *I used the ICD-10 code Z30.2 for code 8110 and it was rejected.*

Z30.2 is listed as "Sterilization - Admission for interruption of fallopian tubes or vas deferentia" and is therefore incorrect. The ICD-10 code for 8110 should always follow on from that of the procedure.

- *How do I bill for telephonic consultations?*

Z76.8 (persons encountering health services in specified circumstances).

- *How do I code for an implant supported bridge?*

Once again, we refer to the reason that the implant and bridge were placed i.e., loss of teeth. Hence the code could be K08.

- *How do I code for re-cementation of a crown?*

Z46.3 (Fitting and adjusting of dental prosthetic device).

- *What is the ICD-10 code to be used for teeth whitening?*

Z41.8 (Other procedures for purposes other than remedying health state)

- *My patient had a car accident on his way to work and fractured his mandible. How do I code for that?*

It is important to note that this is a five-character code. The fifth character, a 0 or 1, indicates an open or closed fracture.It also requires an external cause code, describing how, why and when the incident occurred i.e., S02.61/V43.42, where V43 indicates a car occupant injured in collision with car, truck or van, 4 indicates street or highway and 2 indicates while working for income.

N.B. Because the ICD-10 codes relate to an injury, an external cause code is also required.

- *The patient broke his tooth in a hockey accident. What are the correct codes?*

Again, the five-character code applies: S02.51/W21.30, where W21 indicates striking against or struck by sports equipment; 3 indicates at sports or athletics arena and 0 indicates during sports activity.

While ICD-10 coding might seem cumbersome and unnecessary, it is a statutory requirement to collect this data for an accurate reflection of the burden of diseases experienced in South Africa. It is also a vital part of the claims process. Medical scheme entitlements are based on diagnosis and procedures which determine how much money is made available for each benefit. Thus, if the patient or the doctor does not divulge such information, the scheme can rightly question what they are paying for, and may refuse payment for the services rendered.

If there are any further queries regarding ICD-10 coding, kindly email **Dr Tinesha Parbhoo** at **clinical@sada.co.za**. A general list of ICD-10 codes may be accessed at the following link: https://icd.who.int/browse10/2019/en

The WHO has also made available an ICD-10 interactive self-learning tool, together with full ICD-10 training, which will be helpful for practitioners and support staff alike. This tool is available at:

https://apps.who.int/classifications/apps/icd/icd10training

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Vuyo Primary
Footprints Preparatory School
Mmabatho Educare Centre

KwaZulu-Natal

Athlone Primary School
Dolphin Coast Primary
Mouthaven Primary
Mitchford Primary School

Limpopo

Good Hope Primary School
Pepps Polokwane
Pietersburg Noord Primary
Sione Primary School

North West

Vyfhoek Primary
Laerskool President Pretorius
Berts Bricks Primary School
Laerskool Baillie Park
Es La Grange Special School

Free State

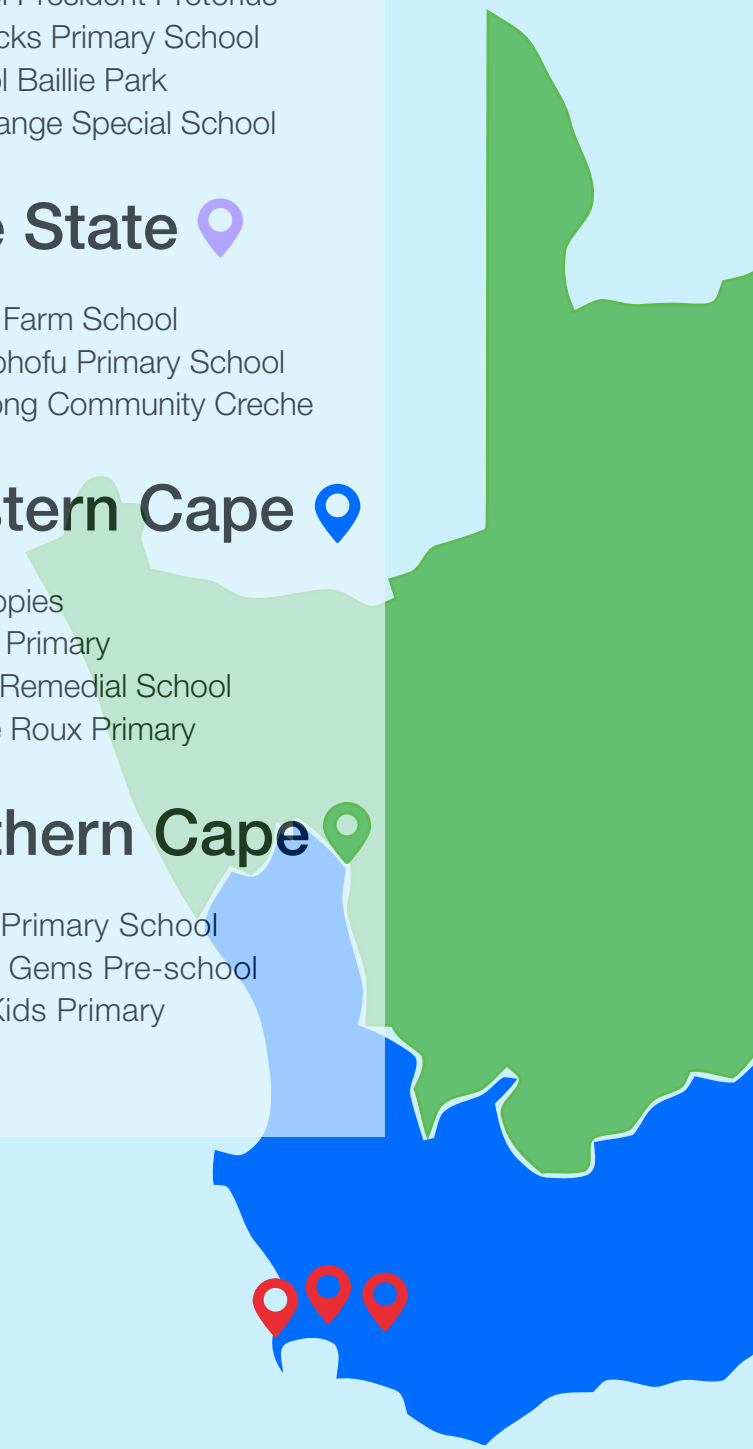
Vierhoek Farm School
Moremaphofu Primary School
Kutlwanong Community Creche

Western Cape

Akkerdoppies
Bottelary Primary
Dunatos Remedial School
Daniel Le Roux Primary

Northern Cape

Olympic Primary School
Precious Gems Pre-school
Sunset Kids Primary



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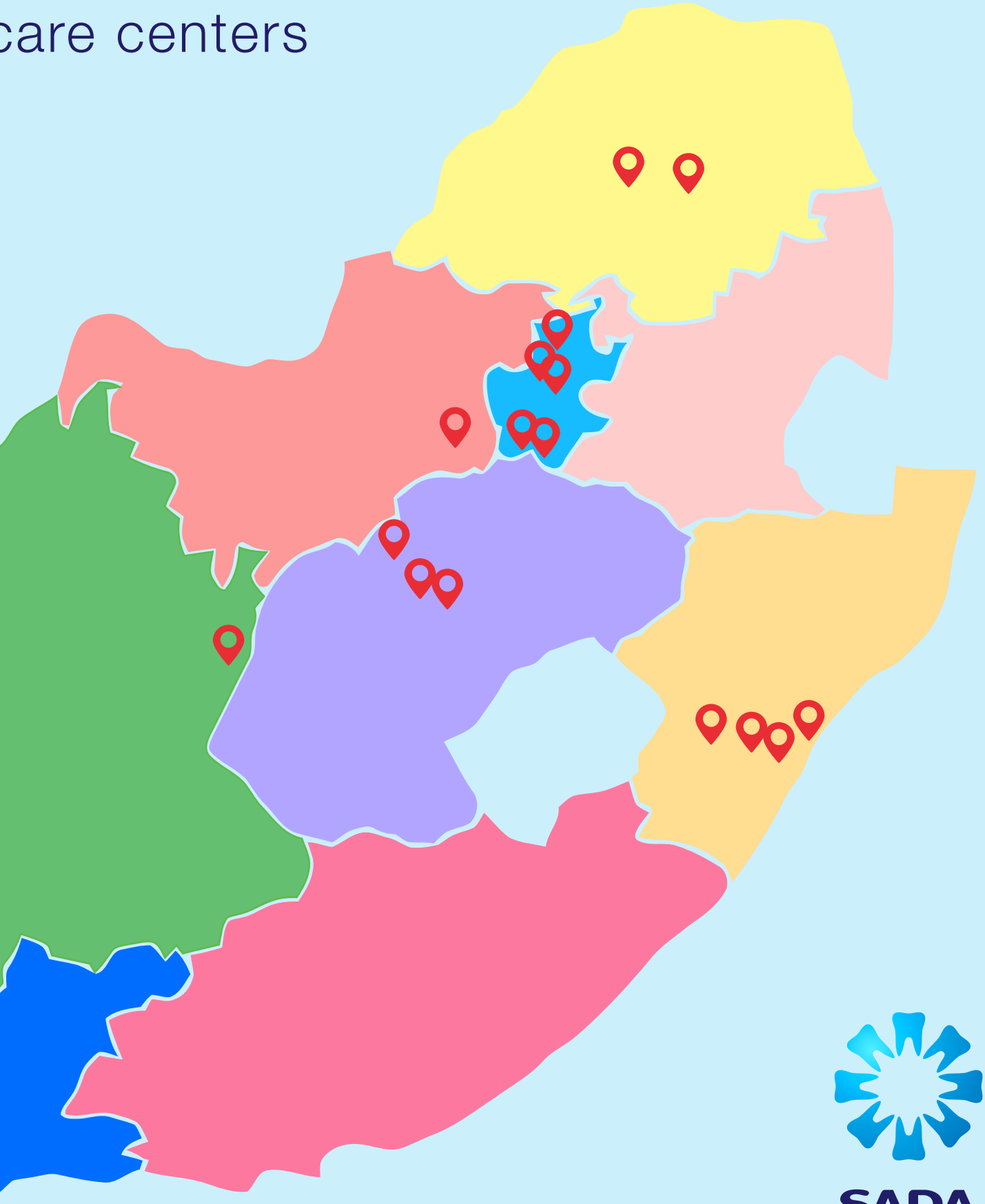

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A comparative analysis of in-office vital 6% hydrogen peroxide activated charcoal tooth whitening treatment enhanced with an 810nm diode laser, compared to 35% hydrogen peroxide bleaching

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SI Hassim[1], TA Muslim[2]

ABSTRACT

Background
Laser dental bleaching is considered to be a contemporary approach to enhancing the in-office power bleaching procedure.

Objective
To investigate if laser enhanced 6% Hydrogen Peroxide (HP) solution is equivalent to 35% HP solution over a two-visit power bleaching treatment protocol.

Materials and methods
In a randomised double-blinded clinical trial, 43 patients were assigned to a group that received either the laser -enhanced 6% Hydrogen Peroxide (n=21) treatment, or the standard 35% Hydrogen Peroxide (n=22) treatment, over two visits, with a one-week interval. Activated charcoal HP paste was prepared for both groups. The laser enhanced 6% HP group received a dosage of 90 J/cm^2 per bleaching cycle using 810nm diode laser.

Tooth colour was measured at the beginning and end of each session registering parameters L*, a* and b*, and tooth sensitivity. The calculated difference between these parameters, ΔE, was the primary data focus. The mean ΔE over the treatment duration was used to answer the research question by a t-test to evaluate group differences at 5% significance level.

Results
The analysis revealed that the null hypothesis could not be rejected and the results were inconclusive.

Conclusion
The observations expound the idea of an absorption enhancement mechanism, rather than a free radical activation, as the technique for improving bleaching outcomes.

Author affiliations:
1. **Shabeer I Hassim:** *BDS (Medunsa), MSc (Lasers in Dentistry) (Rheinisch-Westfälische Technische Hochschule Aachen),* Private Dentist, Durban, South Africa.
   ORCID Number: 0000-0002-5559-7188
2. **Tufayl A Muslim:** *BDentTher (UDW), MSc. [DENT] (UWC), MTech (Qual) (DUT), PhD (UWC), PG Dip Higher Education (UKZN), PG Dip Law (UKZN),* Acting Academic Leader and Lecturer, Discipline of Dentistry, School of Health Sciences, University of KwaZulu-Natal, Westville Campus, University Road, Durban, South Africa.
   ORCID Number: 0000-0001-5824-6191

Corresponding author: Shabeer I Hassim
Private Dentist, 35 Waverton Road,
Essenwood, Durban, 4001, KZN, South Africa.
Email: docshabz@aol.com

Author contributions:
1. **Shabeer I Hassim:** Principal Researcher, write up - 85%
2. **Tufayl A Muslim:** Review and revision of write up - 15%

INTRODUCTION

Dental bleaching is one of the eminently popular and safest cosmetic procedures available. With an increase in the demand for this procedure comes an increased need for this treatment to be administered efficaciously.

Dental bleaching is the process of altering the natural colour or shade of teeth, rendering them whiter and aesthetically improved in visual colour perception. Dental bleaching is differentiated from tooth whitening which covers a broader spectrum of which bleaching forms an aspect (for example, whitening toothpaste whiten teeth but do not bleach them).

In terms of patients' rationalisation, in-office dental bleaching treatments represent a plausibly convenient way to achieve an optimal bleaching result. The panacea of an instant tooth whitening seems alluring enough for those seeking whiter teeth. The modern patient expects an immediately acceptable, perceived aesthetic improvement in tooth colour as a determinant of value for both monetary and time inputs.

With higher concentrations of hydrogen peroxide at 35% in-office bleaching has been found to be effective but may frequently require multiple visits to produce an opti-

mal result.[1] Clinicians tend to use a combination of home and office treatments to meet patients' expectations while avoiding the costs of additional chair time associated with multiple in-office treatments.

Laser optimisation of the in-office power bleaching treatment is a contemporary approach to accelerate peroxide bleaching that basis itself predominantly on the physical means of heat transfer to the bleach. Laser-tissue interactions warrant careful consideration so as not to cause tissue damage and unwanted side effects yet optimally improve bleaching efficacy.

BACKGROUND AND LITERATURE REVIEW

Hydrogen peroxide (HP) has been used as a dental bleach since 1884.[2] Its use, efficacy and safety as suitable dental bleaching agents have been well established.[3] Application of HP as a bleaching agent occurs in a variety of formats [over-the-counter products, dentist-administered take-home products, and dentist-administered in-surgery whitening (power bleaching)]. The power bleaching technique aims to provide a maximum bleaching result in a relatively short space of time (the duration of a dental appointment).

Bowles and Ugwuneri[4] designed an *in vitro* model able to detect the presence of HP in the pulp of bleached teeth. They concluded that dental hard tissues exhibit substantial permeability to HP and that this permeability increases with increasing temperature.[5] Recently, Micro-Raman spectroscopy (MRS) and Fourier transform infrared photoacoustic spectroscopy (FTIR-PAS) were used to measure spectra of specimens. MRS showed that HP crossed enamel had a marked concentration at the dentine-enamel junction (DEJ) and accumulated in dentine.[6]

FTIR-PAS showed that HP modified dentine's organic compounds demonstrated by a decrease in amides I, II, III absorption band intensities".[6] This study showed a relationship between HP diffusion and oxidation of dentine organic components. Other studies have substantiated oxidation of organic components rather than the previous chromophore theory as the predominant mechanism in tooth bleaching.

A 2018 study concluded that dentine phosphoprotein (DPP), the main non-collagenous protein, was responsible for the fluorescence and colour of normal dentine.[7] Moreover, HP might whiten normal dentine by oxidising DPP - specifically, the aromatic amino acids (AAAs) in DPP.[7] Oxidation of organic components of dentine is concluded to be the predominant theory of the microscopic mechanism of tooth bleaching.

Enamel and dentine behave like semi-permeable membranes, and as such, follow the description of diffusion of HP by Fick's Second Law.[8,9] According to Fick's law, flux, or the rate HP will move through enamel and dentine, is equal to the gradient (pressure differential/thickness) multiplied by the diffusion constant.

Fick's law reveals that in diffusive processes there is a fundamental relationship with the time of HP application as well as the concentration of HP solution. It is essential to understand this relation as it is vital in correlating efficacy of HP in bleaching models. The efficacy of the use of high concentration HP gels, typically at 37%, is well established in power bleaching techniques; the higher the concentration of the bleaching solution, the quicker a shade change will occur.[10]

The relationship between peroxide penetration and efficacy cannot be linearly correlated, as the system is complex with inter-dependable factors. Increased penetration, as well as efficacy, was noted for increased concentration[1,11] and time[9,12,13] Torres et al., have shown that chemical activation resulted in decreased penetration but enhanced efficacy.[1] Increased pH did not improve efficacy,[15] but etching enamel with 37% phosphoric acid improved HP penetration.[16] There was both improved efficacies as well as HP penetration in younger teeth with larger dentinal tubules.[17,18]

The addition of heat or light may speed up the catalytic reaction as well as improve the diffusion of HP. Other studies have noted Increased HP penetration for heat as well as laser activation.[4,7,12] The dependence of the rate of a chemical reaction on temperature can be explained by the Arrhenius equation which states that as an increase in temperature occurs, then an increase in the fraction of molecules that have kinetic energies higher than the activation energy of the reaction occurs.

Therefore, the total activation energy of the reaction decreases, and as a result the rate of reaction increases. The addition of heat and use of lights and laser have not comprehensively been shown to enhance the bleaching effect or efficacy.[20,21]

A protocol of creating a sealed environment during in-office bleaching, with claims of increased efficacy, called the "compressive bleaching technique" has been introduced, efficacy.[22] Here the power-bleaching gel is applied using a bleaching tray and sealing the borders with a light-cured resin barrier.

Studies using a similar sealed technique with low concentration HP show both ΔE and shade score changes were higher for the sealed bleaching group than the conventional bleaching group. Therefore, the effectiveness of the in-office bleaching protocol increased when the sealed bleaching technique was used.[23] *In-vitro* analysis of sealed bleaching technique using high concentration HP showed increased penetration of HP but similar efficacy in terms of colour change.[24]

Currently, there are limited studies that compare or evaluate the efficacy of a 6% HP solution. In a study using a concentration of 6% HP, patients achieved a change of at least 5 units delta E (ΔE) (a quantitative colourimetric calculation difference from spectrometer measurements taken before and after treatment) in a 9-month follow-up which was considered effective.[25]

In a split-mouth study which evaluated a 6% HP enhanced by titanium dioxide nanoparticles activated by hybrid light (laser/LED) showed delta E (ΔE) changes higher than 5 for the 6% group over three appointments with a total contact time of 72 minutes.[26] However, this was significantly lower than the control group using 36% HP.[27]

RATIONALE

A crucial policy change in 2011 resulted in The European Commission issuing a new directive (Council Directive 2011/84/EU) regarding tooth whitening products, classifying these as cosmetics products. Formerly classifying them as medical devices under the Medical Device Directive (MDD 93/42/EEC). The new directive also refers to restrictions and conditions of use of HP in teeth bleaching products -

"Only tooth whitening products with less than 0.1% HP may be sold on the open market in the European Union and products containing between 0.1%-6% HP content may only be sold to dentists, and only under the following conditions: ***a.*** *The first use of each cycle of the product must be completed by a dentist at a clinical examination, after which use may be continued by the patient, and* ***b.*** *The use of these products by clients under 18 years of age is not permitted, even under the supervision of a dentist".*[28]

Before this directive, the variety of dental bleaching products and protocols were assured of success with power bleaching treatments, as long as a high concentration HP is incorporated into their system or technique.[28] The use of a 6% HP solution will not be able to match the efficiency of a 35% HP solution typically required in a power bleaching treatment.

The decrease in concentration will result in an exponential decrease in efficacy.[10] To match the same outcome as a higher concentration peroxide multiple and lengthier applications of lower concentration, HP will be required.[10] Under these conditions, the in-surgery bleaching technique will not be viable, and finding an alternative to enhance the bleaching efficacy of a 6% HP solution will be required.

Heating of the bleaching solution is capable of potentially being the enhancement required to reach the required efficacy. From the Arrhenius equation, each 10°C increment in temperature increases the rate of reaction 2.2 times, resulting in the increased release of hydroxyl radicals from peroxide.[10] The heating of the HP may also lead to increased diffusion of HP into the pulp as well as overheating pulp; Zach and Cohen demonstrated that an increase of a mere 5.5°C in the pulp tissue temperature could cause irreversible pulpal damage.[11,12]

The use of a bleaching gel has shown to provide an insulating effect for heat transfer to pulp tissue.[12,13] A 2006 study by Sulieman et al. recorded surface and pulpal temperatures with and without a bleaching agent and after, irradiation for 30 seconds using a diode laser at power settings of 1W, 2W or 3W and was able to show that the presence of the bleaching agent with photoabsorbers reduced the temperature rise at all power settings by 86-88%. However, they only recommended the 2W setting as being safe and being within the parameters described by Zach and Cohen.[12]

In another study, Baldissara et al. were able to demonstrate that increase in pulpal temperatures between 8.9°C and 14.7°C in humans showed no clinical or histological signs of pulpal damage14. Based on these two studies' findings, the use of a diode laser at 3W with 30s irradiation or a dose of 90 J/cm2 can be considered as safe and to not cause pulpal damage.

We need to investigate the possibility of a 6% HP solution enhanced with 90 J/cm2 of laser energy being able to match the efficiency of a 35% HP solution. This study investigates the possibility of a 6% HP solution enhanced with 90 J/cm2 of laser energy being able to match the efficiency of a 35% HP solution.

Cartesian shade differentiation

The CIE system, made up of the tristimulus values (X, Y and Z), on a Cartesian Plane, is the basis of colour language and the way we communicate accurate and precise colour values globally. The representation of RGB or primary colours is by values on the X, Y and Z axes. These XYZ coordinates are useful in colour matching and colour identity, that is, whether two colours match, but are not, in the calculation of colour difference. The difference between two sets of XYZ tristimulus values does not yield an accurate numerical value as a representation of this difference. Numerous colour-difference formulae emerged worldwide for a variety of fields and applications. In response to the need for global uniformity, the Commission Internationale de l'Éclairage (CIE), an international authority on light and colour, adopted the CIELAB system in 1976.[30]

The colour difference formula adopted by CIELAB is a technique of converting the XYZ tristimulus values to produce a precise colour difference value. The L*a*b* system organises all existing colours within a three-dimensional colour space. L* represents the degree of lightness and ranges from 0 (black) to 100 (white); a* represents the green-red axis, while b* represents the blue-yellow axis. The colour comparison before and after treatment computed by the differences between the two colours (ΔE), which is calculated using the formula:

$$\Delta E = \sqrt{((\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2)}$$

CIELAB is entirely dependent on spectrophotometric measurements of colour; it cannot be used routinely without a colour measurement device, and there is no standard CIELAB colour atlas available.[30] An instrumental method for shade matching has been preferred over the visual evaluation because it improves the process practically and has statistically higher reliability.[31]

A spectrophotometer is an analytical instrument that is used to quantitatively measure the reflection or transmission properties of a material as a function of wavelength. The VITA Easyshade V (VITA Zahnfabrik, Bad Säckingen, Germany) is a contemporary portable spectrophotometer was used in this study.

The Easyshade V handpiece has a 5mm diameter probe, which contains three spectrometers. One spectrometer continuously monitors the output of the lamp during the calibration and measurement process. The other two spectrometers analyse the light that is internally scattered (not absorbed) by the tooth structure.[32]

Several factors could affect clinical performance of the intraoral spectrophotometer, positioning on tooth, translucency variations caused by background lighting as well as variations in operator techniques.

AIMS

This study aims to investigate if a laser enhanced 6% HP solution is equivalent to a 35% HP solution over a two-visit power bleaching treatment protocol, by aiming to prove the following superiority research question:

H0 - Null hypothesis: The in-office vital 6% HP (Group 1/experimental), AC tooth whitening treatment protocol with a diode laser (810nm) does not cause colorimetric changes compared with the gold standard 35% HP (Group 2 -Control) bleaching.

H1 - Experimental hypothesis: The in-office vital 6% HP, AC tooth whitening treatment protocol with a diode laser (810nm) causes colorimetric changes compared with the gold standard 35% HP.

MATERIALS AND METHODS

This clinical study was approved by the Biomedical Research Ethics Committee (BREC) of the University of KwaZulu-Natal (BFC673/18). The study took place between April-May 2019 at a private dental clinic. Forty-seven volunteers were selected and informed consent was obtained.

The bleaching study was a randomised, double-blinded (patients and evaluator) clinical trial with a two-arm parallel-group design without any adaptation in randomisation or conduct to proof a superiority question. The patients were invited to participate in the study through social media advertising, the demographics of which were determined beforehand. Respondents directed to an online questionnaire as the first phase of screening for eligible participants. The final phase of screening involved a physical examination conducted by the primary investigator.

A total of 83 patients were examined to check if they met the following eligibility criteria of the study: older than 18 years of age, good general and oral health, as well as anterior teeth without restorations, previous bleaching procedures, cervical lesions, or dental pain.

Pregnant or lactating patients, gingival recession, periodontal disease, smokers or had other oral-staining habits, tetracycline stains, had moderate or severe fluorosis, orofacial tumours, trauma, orthodontic treatment, or tooth malformation, were taking analgesic, anti-inflammatory, or antibiotic drugs, or if they exhibited high anxiety were excluded.

Four patients were excluded and forty-seven patients were admitted to the study. Informed consent was obtained. Two trained operators (registered dentists) performed the bleaching treatments. The operators were aware of the treatment protocol for each patient. A study coordinator was responsible for patient appointment liaisons, conducting the randomisation, and maintaining, storing and transmitting trial data to the statistician.

Group allocations were performed by random drawing, using Microsoft Excel 2016, from coding assigned to each participant. Group 1 was the experimental group, treated with 6% hydrogen peroxide (HP6) activated by diode laser. Group 2 acted as a control, receiving the standard 35% hydrogen peroxide (HP35) treatment.

Sample size calculation

Calculation of the sample size was done by using nQuery 7.0. Previous studies showed that application of in-office power bleaching agent of 35% HP HP35 would lead to a (ΔE) value of 7.0±2.0 after two bleaching sessions.[25] Two study groups each received different treatments, and a continuous primary endpoint was measured.

The primary outcome of this study was efficacy determined by colour alteration (ΔE). To have an 80% chance of detecting significance at the level of 5%, considering an increase in the primary outcome measure from Δ7 in the control group to Δ5 in the experimental group, a minimum of seventeen participants were required in each group. Allowance for a dropout rate of 23% and the total number of participants (n=34) was set to forty-four (Computation: test with homogeneous variance nQuery 7.0, procedure MTT0).

Materials

- For shade measurement - VITA Easyshade V spectrophotometer, S/N H54885 (VITA Zahnfabrik, Bad Säckingen, Germany).
- Activated charcoal powder (Sigma-Aldrich, St Louis, USA).
- Hydrogen peroxide liquid (Sigma-Aldrich, St Louis, USA) in 35% and 6% solution stored in dark bottles.
- Elexxion Pico 5W / 810 nm wavelength Diode Laser (Elexxion, Radolfzell, Germany).

Bleaching protocol

For each bleaching session, the operator mixed the relevant HP solution with AC in a glass dappen dish by incorporating 0.1g of the AC powder per 0.5ml of the HP liquid, namely 6% HP for Group 1 and 35% HP for Group 2.

Standard patient protection, as well as a gingival barrier, was applied to the dry gingiva. The gel mixture was then applied to the enamel surface of the upper and lower six anterior teeth to produce a uniform layer approximately 2 mm thick.

In both groups, the mixture was applied for 20 min, then washed off and a fresh mix of gel placed for another 20 min. In Group 1, however, there was concurrent laser-activation of the gel mixture, cycled twice per each 20 minute application. The handpiece of the diode laser was placed just above the surface of the gel, and applied with a 1 cm spot diameter for 30 seconds per tooth, on a 3W continuous setting. Completion of two bleaching sessions per patient gave a total contact time of 80 minutes.

The interval between sessions was seven days. The re-

levant bleaching solutions were monitored for uniformity by assigned bleaching staff. The bleach timings and laser application timings (where relevant), were also monitored.

Shade evaluation

A dedicated Shade Evaluator employing a strict shade evaluation protocol carried out four evaluations per patient in a separate evaluation room. The evaluator was unaware of the protocol used and only saw the assigned patient number (n1 to n43) when recording the data.

For both pre-operative evaluations (seven days apart) polishing off the teeth was completed before shade measurement. The two post-operative evaluations were carried out immediately on completion of the bleaching sessions.

Steps in the treatment of patients

The following steps were followed:

- Shade evaluated with the Vita Easyshade V spectrophotometer.
- Rubber stent formed using Betasil® Vario Putty with a 5mm window in stent - window on upper left central incisor, centre of tooth; stent on labial aspect with bite stabilising the stent.
- Vita Easyshade calibrated on cradle (calibration block).
- Average base shade setting chosen.
- Probe placed in window of stabilised stent with the probe window sitting flush against the tooth surface.
- When the device held in a stable position, evaluator took single reading - checked - retook - checked - until two corresponding results were obtained. Thereafter three consecutive readings were taken while held in the same position; the device then gave the average of these five readings. If the first two readings did not correspond then the device was reset, recalibrated and probe positioning was adjusted.
- All the data was manually recorded on patient data sheet.
- The above procedure was repeated for all pre- and post-operative measurements using the same stent (per patient) for all procedures.

Concomitant care

Patients were urged to adhere to the following between bleaching visits. Items to be avoided: whitening toothpaste, medications which affect saliva flow, mouthwashes, smoking, consumption of chewing tobacco and other items that may cause oral staining such as “paan” (betel leaf) and “supari” (betel nut). Patients also had to limit consumption of tea, coffee and red wine, patients should not have had any other bleaching or dental care in the days between the two appointments.

All participants were monitored by treating dentists, as well as the shade evaluator. Every participant confirmed full compliance. The interventional phase of this clinical trial spanned three weeks with the total time of participant involvement being approximately one month. Overall, the completed processes from inception to the conclusion took the better part of a year.

Statistical methods

The primary focus is on the description of the mean ΔE between the two arms of the study. For the main study, the data for L*, a*, b* and age, as well as the ΔE, are described in terms of means and standard deviations, statistical measures only will describe the data of the pilot study.

The overall ΔE, calculated as mean ΔE over the duration treatment, is used to answer the primary research question by a t-test to evaluate group differences at the 5% significance level.

To evaluate differences in ΔE, ΔL*, Δa* and Δb* by visit, age, sensitivity and corresponding interactions of visit by age, was computed by the fitting of linear mixed effects models to the data. Statistical computations were conducted using SAS software; in particular, the application of PROC MIXED. A significance level of 5% was set.

RESULTS

The sample for the main study consisted of thirty-two women (82.05%) and seven men (17.95%). Nineteen participants were allocated to the experimental arm of the study (Group 1), and twenty to the control arm (Group 2).

Baseline characteristics

Age and gender distribution

Age distribution appears to be similar between groups. Mean age in Group 1 was around 30 years (SD 8.7) and in Group 2 around 32 years (SD 9.35).

The gender distribution was as follows - Group 1 consisted of 78.95% (15) females and 21.05% (4) males; Group 2 consisted of 85% (17) females and 15% (3) males.

Primary analysis ΔE

Description of mean ΔE across visits amounts by 3.4 (SD 1.8) in Group 1 and by 4.9 (SD 3.2) in Group 2. The mean difference between groups was 1.5 (SD 2.6) with a 95% confidence interval (95% CL: -0.19; 3.23) does not indicate a significant difference at the 5% level (p=0.0798).

Sensitivity analysis ΔE

We do observe a significant dependency of Age on the ΔE (p=0.0041) using an averaged 0.1484 increase in ΔE per patient-year. We do not observe a dependency by group, gender, sensitivity, nor a difference between visits (Tables 1-3).

Table 1. Description of mean ΔE across visits between groups.

Questions	Method	Mean	95% CL Mean		Std Dev
1		3.3637	2.4825	4.2449	1.8282
2		4.8838	3.3788	6.3888	3.2156
Diff (1-2)	Pooled	-1.5201	-3.2296	0.1894	2.6336

Table 2. Statistical analysis of ΔE.

Method	Variances	DF	t Value	Pr > |t|
Pooled	Equal	37	-1.80	0.0798

Table 3. Statistical analysis of ΔE with fixed effects.

Type 3 - Tests of fixed effects				
Effect	**Num DF**	**Den DF**	**F Value**	**Pr > F**
Group	1	33.2	0.12	0.7293
Visit	1	39.3	1.77	0.1908
Visit*Group	1	38	1.67	0.2040
Gender	1	23.7	1.56	0.2238
Age	1	42.1	9.24	0.0041
Age*Group	1	42.8	0.01	0.9277
Sens	1	30.4	1.06	0.3109

Sensitivity analysis: L* measurements

We do not observe any influence of age on the L* measurements, as well as differences between gender, visit as well as treatment groups.

Sensitivity analysis: a* and b* measurements

We do not observe any influence of age on the a* and b* measurements, as well as differences between gender, visit as well as treatment groups.

DISCUSSION

In this randomised double-blinded clinical study, a treatment protocol was devised that could effectively measure the energy transfer from the laser light to the bleaching solution and directly correlate this heat transfer to improved efficacy. The addition of heat being the primary mechanistic means of increasing the rate of absorption of a low concentration HP solution rather than directly catalysing the HP solution to release free radicals implicated in the bleaching process.

The lack of similar studies makes it difficult to compare results, however Bortallato et al., (2015), in a parallel study for in-office tooth bleaching with 6% H2O2/TiO nanoparticles enhanced by an LED/laser system, showed almost identical ΔE values to this study for both the 6% HP and 35% HP groups.[24] The authors assigned the additional bleaching effect to the photocatalyst of the 6% nano-sized hydrogen peroxide (TiO_N).

Of interest to note in this study, the bleaching gels were additionally coloured, and the combination laser/led device was applied with an intensity of 300 mW/cm^2 for 6 minutes, delivering a dose of 108 J/cm^2 compared to a dose of 90 J/cm2 in our study.

Using identical products and parameters as the above study but in a split-mouth study design, Martin et al., (2015)[25] evaluated 6% HP enhanced by titanium dioxide nanoparticles activated by hybrid light (laser/LED) showing delta E (ΔE) changes at visit 2 expressed by mean (standard deviation) similar to this study.
This study was also designed to use a non-commercial

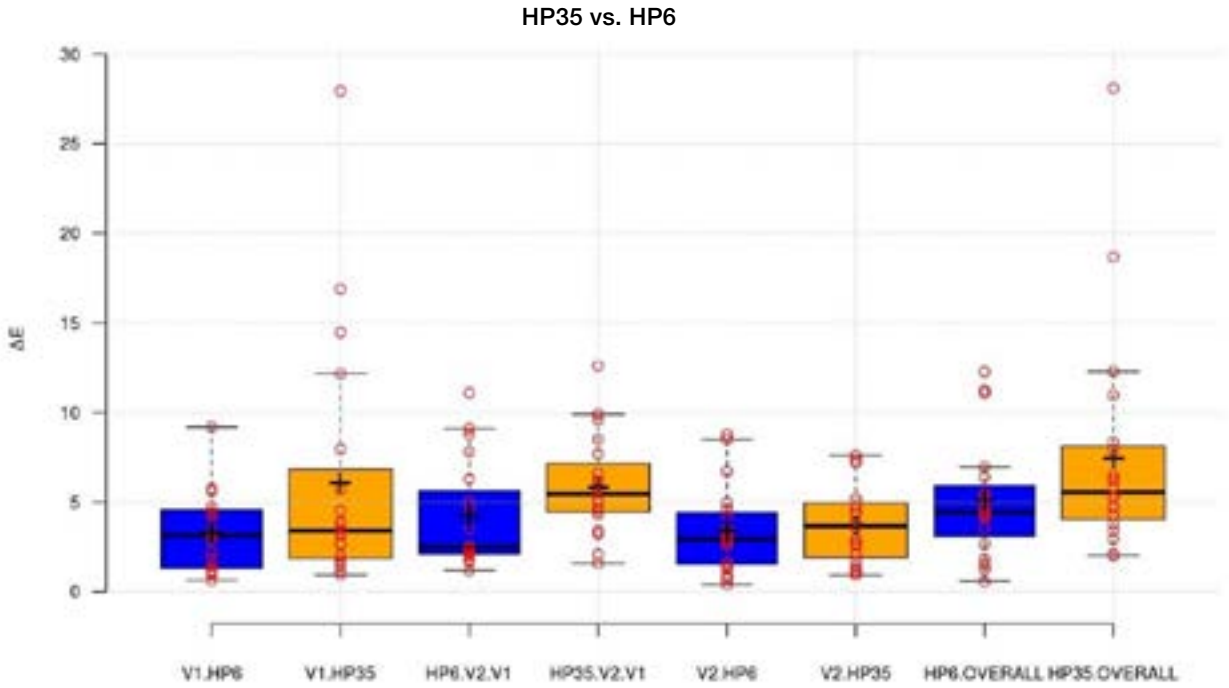

Figure 2. Nature of new cases received 1 July 2020 - 30 September 2020.

Table 4. Boxplot precise values.

Box plot statistics								
	V1.HP6	**V1.HP35**	**HP6.V2.V1**	**HP35.V2.V1**	**V2.HP6**	**V2.HP35**	**HP6.OVERALL**	**HP35.OVERALL**
Upper whisker	9.18	12.16	9.10	9.90	8.49	7.52	6.95	12.28
3rd quartile	4.57	6.83	5.65	7.15	4.43	4.95	5.92	8.13
Median	3.12	3.42	2.50	5.45	2.93	3.67	4.44	5.56
1st quartile	1.30	1.85	2.10	4.45	1.54	1.90	3.09	4.04
Lower whisker	0.64	0.94	1.20	1.60	0.41	0.93	0.58	2.02
Nr. of data points	19.00	20.00	19.00	20.00	19.00	20.00	19.00	20.00
Mean	3.31	6.08	4.28	5.87	3.42	3.69	5.10	7.47

bleaching solution devoid of hygroscopic or humectant effects present in commercial bleaching gels. The absence of humectant in our HP solution may account for the lower efficacy results in comparison to the majority of other studies using commercial high concentration HP gels. The gels can dehydrate the tooth, making them appear whiter. The humectant effect of these gels may also account for the improved efficacy associated with bleaching lamps rather than a direct photocatalytic effect.

Humectants have polar hydroxyl groups and can attract water via the weak hydrogen bonds of the latter; by the process of adsorption, they can attract water from their surroundings. Humectants are sensitive to temperature and humidity in the surrounding air when humidity is, high, it can draw water from the air, but in dry air, it will draw moisture from the tooth. Even though some studies have suggested that some of the initial lighter colour changes may be due to dehydration.[10,33,34] There has been no suggestion, in previous studies, of bleaching lamps enhancing hygroscopic effects of bleaching gels nor of the responsibility of humectants in bleaching efficacy as well as tooth sensitivity.

We cannot correlate ΔE changes from one study to another - the methodology of obtaining the ΔE needs to be similar, as well as consideration of the baseline data.

Clinical interpretation of data

A boxplot of ΔE data for both groups at the various points was incorporated to further interpret data array (Figure 1 and Table 4).

Median vs. mean analysis

The boxplot results show us a closer association between the two groups. Of particular interest was the difference in medians being only 1.12 ΔE units in the overall results (HP35 OVERALL – HP6 OVERALL) showing a much closer association between the two groups than that shown by the difference in means 2.37 ΔE units.

We may be able to argue reasonably, from looking at the data sets, and the presence of significant singular outliers in the HP35 group, that an analysis of the medians rather than the means may provide a closer estimate of the difference. The median analysis also shows lower differences of the other ΔE scores after visit 1 and visit 2 in comparison to the mean analysis for these visits. We cannot conclude or categorically confirm this effect. The “outlier” would increase the SD. As can be seen in Figure 1, the SDs are somewhat different. However, the deviation is in the range of random variation.

Continuity of bleaching post application

The study also sought to assess the possibility that the teeth continued to whiten after the removal of bleach - this would further elucidate the absorption before the activation mechanism of bleaching.

To accomplish this, we measured the difference of ΔE between the end of visit one and the start of visit two for both groups. Both groups adequately displayed the effect of continued bleaching, and mean results were comparatively close. However, in terms of medians, the HP35 group was almost twice that of the HP6 group, an expected result, considering the exponential effect of higher concentration on bleaching efficacy.

During the bleaching process of this study, we accelerated the absorption of low concentration HP with heat from the light. The HP, in turn, reacts with organic components within the tooth, which catalyse the breakdown of HP. The subsequent oxidation of the dental phosphoprotein results in whiter teeth.

If we consider the number of organic components readily available to interact with HP as being limited within a fixed timeframe and consider concentration gradients from the DEJ, then we can theorise a self-limiting effect to bleaching inherent within the tooth. The use of low concentration HP will then be equivalent to a high concentration HP as long as the absorption rate is the same since the bleaching effect is self-limited by inherent factors within the tooth. However, once absorption stops, the residual higher concentration HP can bleach further with time as organic catalyst becomes available or replenished. This model can account for the first quartile of the 35% HP group reaching a high ΔE score of 4.45, compared to the 2.10 score in the 6% group.

Results analysis

The analysis reveals that, concerning the primary endpoint delta E and the statistical model used according to the sample size argument, the null hypothesis could not be rejected. The result is inconclusive. We did not observe a significant difference between 6% HP and 35% HP bleaching groups.

CONCLUSIONS

Dental bleaching is a dynamic process, which is dependent or not only the breakdown of hydrogen peroxide but also the interaction between the tooth and the composition of the hydrogen peroxide solution. A common feature for all practitioners undertaking bleaching is the unpredictability of results. To date, the elucidation for such unpredictability cannot be reasoned by any particular model. The observations of this study, however, further expounds the idea of an absorption enhancement mechanism rather than a free radical activation as the technique for improving bleaching outcomes.

Study outcome

In this study, we were not able to demonstrate that the means difference between the two groups at a 95% confidence interval shows a significant difference at the 5% level ($p = 0.0798$).

The null hypothesis that the in-office vital 6% HP, AC tooth whitening treatment protocol with a diode laser (810 nm) does not cause colourimetric changes compared with the gold standard 35% HP bleaching cannot be rejected. There is no statistical difference between the two groups, on the mean ΔE.
This does not infer that both groups are equivalent con-

cerning ΔE. The study is inconclusive in this direction. The primary aim in power bleaching is to achieve a maximum whitening effect in the space of a single dental appointment, an idea earlier developed in our introduction. In terms of ΔE, we could then correlate this to a maximum ΔE obtainable in a single visit.

When we consider the highly significant grouping in terms of ΔE, that is, the lowest performers (first quartile), we see that the most significant improvement in ΔE occurs post-bleaching, with the higher concentration performing better. It is, for this reason, we can conclude that low concentration 6% hydrogen peroxide, even when accelerated with laser light, is not equivalent to a standard high concentration of 35% hydrogen peroxide solution.

Shortcomings of study

CIELAB was used as a colour differentiation formula however CIEDE 2000 brings colour differences closer to what the human eye actually perceives and is able to give a more accurate colour difference when used in dentistry.[16,17]

Visual shade guide data an important tool in perceptual shade differentiation has not been include in this study. Further work is required investigating the possible role of humectants in dental bleaching.

Conflict of interest/Competing interests

The authors declare no conflict of interest or competing interests. This study was funded by the principal researcher.

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Examining the effect of exposure time on the erosive potential of sour candy

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LS Naidoo[1], SC Onwubu[2], N Murugan[3], S Singh[4]

ABSTRACT

Aim
This study aimed to evaluate the erosive potential of sour candy at a different time of exposure within a laboratory-based setting.

Materials and methods
Fifty human anterior tooth samples were randomly assigned into three groups, namely: sour candy, regular candy A, and deionized water (n=15). Each tooth samples was exposed to a solution containing the sample groups at different time intervals. Vickers hardness tester was used to measure the surface hardness pre- and post-exposure.

The mean surface hardness value measured was compared using a paired sample test ($\alpha = .05$). Raman spectroscopy was used to study the change in the enamel structure in all sample groups.

Results
A significant difference in the surface hardness value was measured pre and post-exposure in all the sample groups ($P<0.01$). The samples exposed to sour candy had the highest tooth surface loss. In terms of the time of exposure, it was found that prolonged exposure had a significant effect on the surface hardness ($P<0.01$). The Raman intensity change confirmed that samples exposed to sour candy, after 2 hrs of exposure, had the highest loss of structural integrity.

Conclusion
The study conclude that sour candies are very erosive and its impact enhances with time.

Keywords
Acids, erosion, tooth enamel, sour candy.

Author affiliations:
1. **Lesley S Naidoo:** *B.D.Th,* Discipline of Dentistry, School of Health Sciences, University of KwaZulu-Natal (UKZN), Durban, South Africa. ORCID Number: 0000-0002-1774-0705
2. **Stanley C Onwubu:** *PhD,* Chemistry, Durban University of Technology (DUT), Durban, South Africa. ORCID Number: 0000-0002-4499-1534
3. **Nelisha Murugan:** *Msc,* Microscopy and Microanalysis Unit (MMU), University of KwaZulu-Natal (UKZN), Durban, South Africa. ORCID Number: 0000-0003-3936-5798
4. **Shenuka Singh:** *PhD,* Discipline of Dentistry, School of Health Sciences, University of KwaZulu-Natal (UKZN), Durban, South Africa. ORCID Number: 0000-0003-4842-602X

Corresponding author: Stanley C Onwubu
Chemistry, Durban University of Technology (DUT), Durban, South Africa.
Email: 21445599@dut4life.ac.za

Author contributions:
1. **Lesley S Naidoo:** Principal researcher - 35%
2. **Stanley C Onwubu:** Writing article - 35%
3. **Nelisha Murugan:** Writing article - 15%
4. **Shenuka Singh:** Advisor - 15%

INTRODUCTION

Dental erosion is characterized by the loss of tooth substances by chemical processes mainly acids of non-bacterial origin.[1] From an epidemiological perspective, dental erosion is highly considered a significant dental problem in both adults and children with a prevalence of 25.11% to 51.6%, respectively.[2]

Moreover, studies[3,4] have directly associated the onset of dental erosion with an increased in the consumption of diets that is rich in acidic content. In South Africa, for example, it is reported that diets and lifestyles are changing with significant consequences for non-communicable disease.[5] The consequence of this is the high incidence of dental caries and erosion of the dentinal surface.[6]

Furthermore, it has been reported in the literature that several intrinsic (chronic vomiting) and extrinsic (acidic foods and drinks) factors influence the degree of erosive wear. Zero and Lussi,[7] however, suggest that the frequency and duration of exposure to erosive agents are important considerations in the onset of dental erosion.

Given that the residential time of candies in the oral cavity tends to be prolonged,[8,9] the consumption of acidic candies is now recognized as a potential risk factor for the onset of dental erosion.[10] Particularly, sour candies possess high adhesive properties to the tooth surface which require a better knowledge about its erosive potential.[11,12]

More worrisome is that the level of protection provided by saliva may not be sufficient to prevent the formation and progression of erosion.[13] In an attempt to manage dental erosion, a comprehensive understanding of the role of pH and time plays in the onset of dental erosion will be highly useful for oral care providers. While several studies have reported that the salivary pH after the acidic drinks requires one to fifteen minutes to return to normal,[14,15] there is, however, limited evidence on the erosive potential of sour candies on tooth enamel at different times of exposure. This study aimed to examine the erosive potential of sour candy at a different time of

exposure within a laboratory-based setting. The hypothesis tested was that the time of exposure would have no significant impact on the prepared tooth enamel samples.

MATERIALS AND METHODS

Various brands of candy were purchased from grocery stores in Durban, South Africa. The candies were differentiated and marked as sour candy and regular candy types. The candies were subject to pH analysis by dissolving 1 gram candy and 5 ml deionized water. The solution was constantly agitated at a low speed of 600 rpm for 5 minutes. A pH meter (Starter 300, Ohaus Incorporation USA) equipped with a temperature sensor was constantly used to monitor changes in the pH reading. Sour candy pH range was predominantly between pH 2 - pH 3 whilst regular candies were predominantly between pH 4 - pH 6. Two popular brands of candywere selected from the candy groups; 1. Fun sour worm candy (sour candy), and 2. Hello kitty Jelly belly (regular candy).

Preparation of enamel specimens

Fifty recently extracted human anterior teeth with no visible defects or prior carious lesions were selected. The enamel specimens (approximately 6 mm x 6 mm x 3 mm) were prepared using a low-speed diamond cutter after the removal of the roots. The prepared enamel specimens were randomly assigned to three different groups based on candy type and pH (Table 1). Each sample was equally divided by placing a central indentation using a low-speed diamond bur to differentiate the surface for exposure (n=3). The sample base was placed on a composite resin for stability, ease of use, and light-cured. A permanent marker was used on the resin base to identify and orientate the specimen.

The control surface (unexposed enamel surface) was pro tected using clear nail varnish (coty topcoat). Samples were subsequently immersed in each of the candy solutions (50 ml) at the specified immersion time intervals under constant agitation (100 rpm at room temperature), then rinsed with deionized water and air-dried. The clear nail varnish was removed using acetone and rinsed again with deionized water and air-dried.

Hardness test

The surface microhardness of each sample specimen pre- and post-exposure was measured and recorded using a Vicker hardness measuring device. A 200g load was used to make an indentation on the enamel surface.

Thereafter, the loaded diamond was allowed to sink and rest on the enamel surface for 15 s. Four different measurements were obtained for each sample and the average Vickers hardness recorded used for statistical analysis.

Raman Spectroscopy analysis of specimens

The changes in the mineral content of the specimens were observed using a Raman (Perkin Elmer *precisely* Raman-station 400). The Raman analysis was done on all the samples with the green laser power set at 70mW, exposure every 10 seconds for 3 seconds at a time. Using a sampling area of 20 x 20 micro, five different measurements were done for each sample and the average was used for statistical analysis.

Statistical analysis

Using statistical package (SPSS v26; IBM Corp), the mean hardness value measured of the enamel specimens pre- and post-exposure were evaluated with a paired sample test (α =.05).

RESULTS

Surface hardness

The mean surface hardness after 2 min of exposure is shown in Table 2. A significant difference was observed pre-and post-exposure in all the sample groups. However, the samples exposed to sour candy had the highest surface loss mean difference whilst the lowest surface mean surface loss were found in specimens exposed to DW.

The mean surface hardness after 10 min of exposure is shown in Table 3. A significant difference was observed pre-and post-exposure in all the sample groups. However, the samples exposed to sour candy had the highest surface loss mean difference while the lowest was measured for the specimens exposed to DW. The mean surface hardness after 15 min of exposure is shown in Table 4. A significant difference was observed pre-and post-exposure in all the sample groups. However, the samples exposed to sour candy had the highest surface loss mean difference while the lowest was measured for the specimens exposed to DW.

The mean surface hardness after 1 hr of exposure is shown in Table 5. A significant difference was observed pre-and post-exposure in all the sample groups. The samples exposed to sour candy had the highest surface loss mean difference. It was, however, observe that the mean difference loss measured in the specimens exposed to the candies were the same.

The mean surface hardness after 2 hrs of exposure is shown in Table 6. A significant difference was observed pre-and post-exposure in all the sample groups. The samples exposed to sour candy had the highest surface loss mean difference while the lowest was measured for the DW.

Spectroscopy assessment

The change in the mineral content of the enamel pre-and post-exposure at a different time is given in Figure 1. There is clear evidence in the plotted subsets of the data for demineralization of the enamel as pH decreases (especially for sour candy (Fig 1B)), and also for the increase of demineralization with exposure time (especially at longer exposure times (Fig 1B (e)).

The demineralization evidence is in both the decrease in intensity of the primary peak (associated with PO4

ion) around 960 cm^{-1} and also in the decrease of the secondary peak around 1070 cm^{-1} that is associated with the presence of carbonates. Hence, it can therefore be said that decrease in the peak intensity confirmed the demineralization of the tooth enamel. This was even more significant with the samples exposed to sour candy and for a longer period of time (Figure 1A (e)).

DISCUSSION

In the recent decade, there has been an increase in enamel erosion amongst adults, adolescence, and children due to the high consumption of candies.[16] The purpose of this study was to examine the erosive potentials of sour candy on tooth enamel at a different time of exposure.

This study found that the pH of the sour candy was lower (pH 2) than that of the regular candy (pH5). Furthermore, the study results explicitly showed that there were significant differences pre and post-exposure to sour candy, regular candies at each time of exposure.

This notwithstanding, the decrease in surface hardness was much more significant for the sour candy. The high decreased in enamel surface hardness may be attributed to the pH of the sour candy.

Table 1. Sample groups.

Sample group	Brand name	pH	Exposure time	Type of acids
Deionized water (control)	DW	6.2	2 min, 10 min, 15 min, 1 hr, and 2 hrs.	N/A
Sour candy	1. Fun sour worm candy	2		Citric and Lactic
Regular candy A	2. Hello Kitty Jelly belly	5		Acid regulators

Table 2. Mean surface hardness after 2 min of exposure.

Sample group	Exposure	Mean (SD) Kg/mm²	Mean difference	*p*-value
DW	Exposed	350±14.7	-2.25	0.003
	Unexposed	352±15.0		
Sour candy	Exposed	344.25±32.7	-15	0.001
	Unexposed	359.25±32.7		
Regular candy	Exposed	398±30.3	-4.25	0.001
	Unexposed	402.2±30.4		

Table 3. Mean surface hardness after 10 min of exposure.

Sample group	Exposure	Mean (SD) Kg/mm²	Mean difference	*p*-value
DW	Exposed	394.5±25.6	-7.8	0.000
	Unexposed	402.3±26.1		
Sour candy	Exposed	402±15.2	-21.8	0.002
	Unexposed	423.8±13.0		
Regular candy	Exposed	382±10.6	-11	0.001
	Unexposed	393.2±10.6		

Table 4. Mean surface hardness after 15 min of exposure.

Sample group	Exposure	Mean (SD) Kg/mm²	Mean difference	*p*-value
DW	Exposed	378±39	-7.2	0.000
	Unexposed	385±38.7		
Sour candy	Exposed	343.5±29.4	-22.7	0.014
	Unexposed	366.3±23.4		
Regular candy	Exposed	378±39	-7.2	0.000
	Unexposed	385±38.7		

Table 5. Mean surface hardness after 1hr of exposure.

Sample group	Exposure	Mean (SD) Kg/mm²	Mean difference	*p*-value
DW	Exposed	243.5±23.9	-18	0.003
	Unexposed	261.5±27.2		
Sour candy	Exposed	339±34.4	-42	0.001
	Unexposed	381±38.8		
Regular candy	Exposed	384.5±12.4	-17.5	0.000
	Unexposed	402.0±12.7		

Table 6. Mean surface hardness after 2 hrs of exposure.

Sample group	Exposure	Mean (SD) Kg/mm²	Mean difference	*p*-value
DW	Exposed	383±16.4	-9.8	0.003
	Unexposed	392.8±16.1		
Sour candy	Exposed	334.3±21.7	-50.3	0.000
	Unexposed	384.5±23.2		
Regular candy	Exposed	381.5±23.9	-31	0.000
	Unexposed	412.5±26		

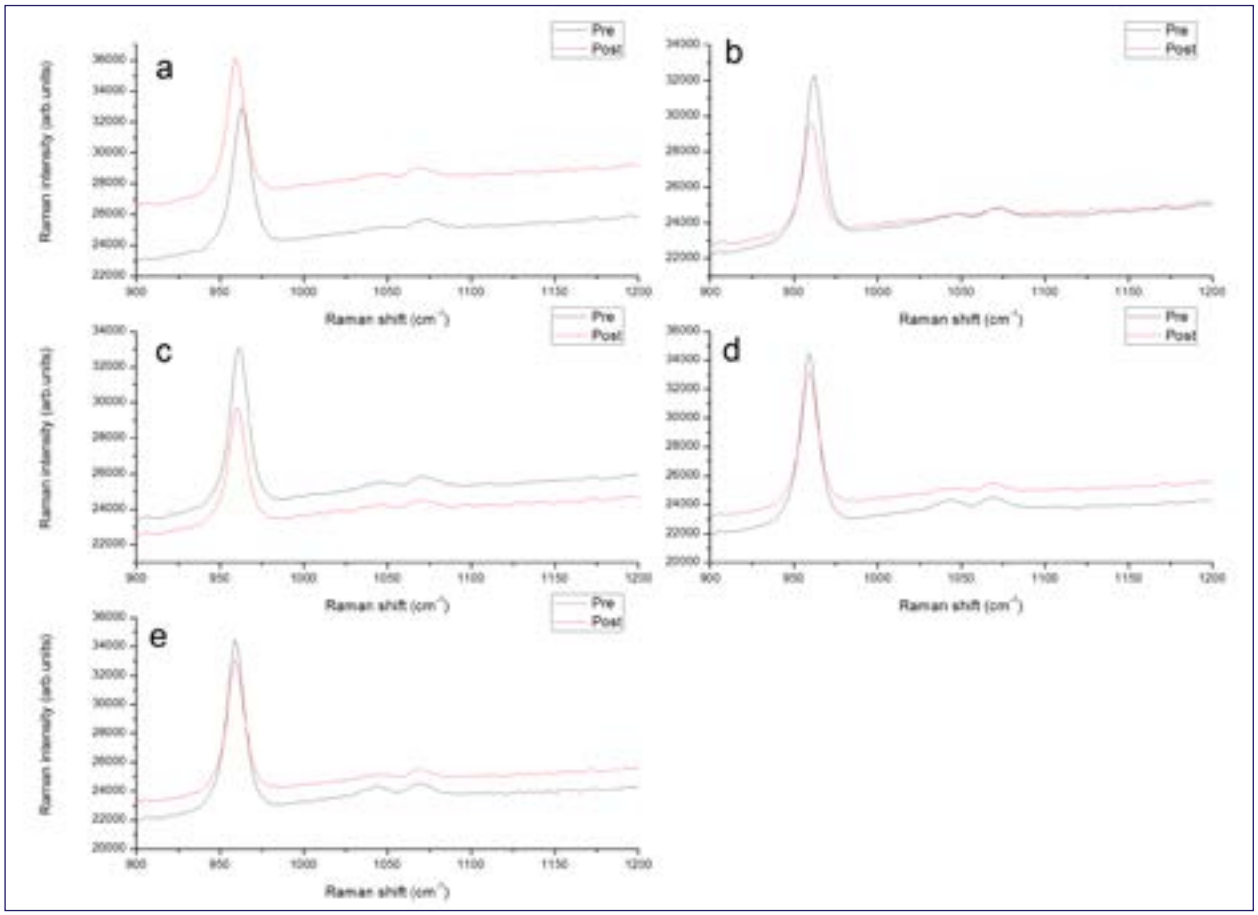

Figure 1. Raman spectroscopy shift for tooth specimens exposed (A) DW; (B) Sour candy, (C) Regular candy (a-e: time interval of exposure).

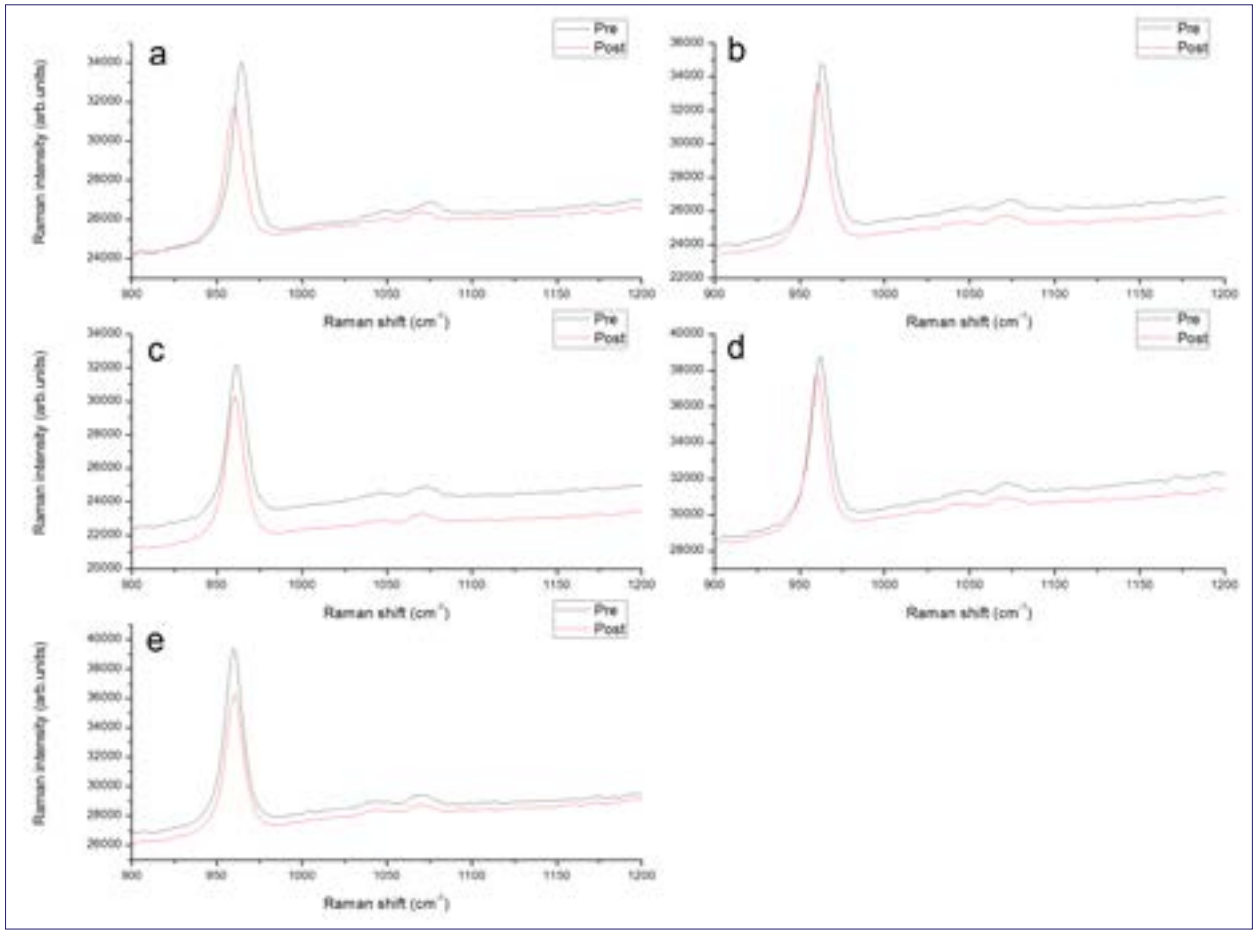

Figure 1. Raman spectroscopy shift for tooth specimens exposed (B) Sour candy (a-e: time interval of exposure).

Of particular importance, clinical evidence has shown that salivary pH reaches a value as low as 2.96 immediately after the consumption of sour candy.[16] This indicates that sour candy may be more erosive than the regular candies, and thus present a more detrimental effect on the enamel tooth integrity. The study findings are also in agreement with El-Marakby[17] that sour substances may lead to reduce enamel surface hardness.

Apart from pH, other authors reported that the frequency, time of exposure, the type, and concentration of acid affect enamel erosion.[18,19] Consistent with this, it was observed that the enamel decrease in sample groups exposed to sour after for 2 hrs. This is particularly concerning, given that children who consumed sour candies more than twice, once daily and 2-4 times per week are nearly 24, 18, and 8 times more susceptible to dental erosion and subsequent tooth decay due to enamel vulnerability.[16]

Equally concerning, it was found that both regular candies at pH 5 and 6 were significantly also erosive (Table 6). While this pH is near the saliva pH, the acidic concentration in the candies may have contributed to their erosive effect.

According to Farias, de Oliveira,[20] candies contains acidic components such as citric, phosphoric, ascorbic, malic, tartaric, oxalic, carbonic, and fumaric acids.

The presence of the aforementioned acids may be attributed to the post erosion measured in the candies used in this study (Table 1). This is in agreement with other studies[21,22] in that the microhardness of enamel after candy consumption decreases.

Furthermore, the spectroscopy analysis of the tooth samples pre-and post-exposure was also used to quantify the erosion effect of the candies. Onwubu, Mdluli[23] revealed that a health enamel tooth displays a strong phosphate symmetric stretching mode (v1 PO4) at 960 cm^{-1}. In this study, it was found that the intensity of the PO4 peak decreased in all the samples after the erosion treatment.

This also agrees with the Kim, Son[24] that a significant reduction in the intensity of peak at 960 cm^{-1} suggests an alteration in the structure of stoichiometric apatite during erosion. Hence, it can, therefore, be said that a decrease in the peak intensity confirmed the demineralization of the tooth enamel (Figure 1 A (e)).

Of interest, samples exposed to deionized water also showed some degree of demineralization. It has been reported in the literature that demineralized water is highly aggressive.[25] The plausible explanation for this may be due the absence of protective calcium in the water. According to Onwubu, Mdluli,[26] calcium or calcium-containing materials offers protective effects against erosive attacks.

From a public health perspective, the findings from this study are highly beneficial to an oral healthcare provider in helping them to develop preventative strategies for the early detection and management of dental erosion.

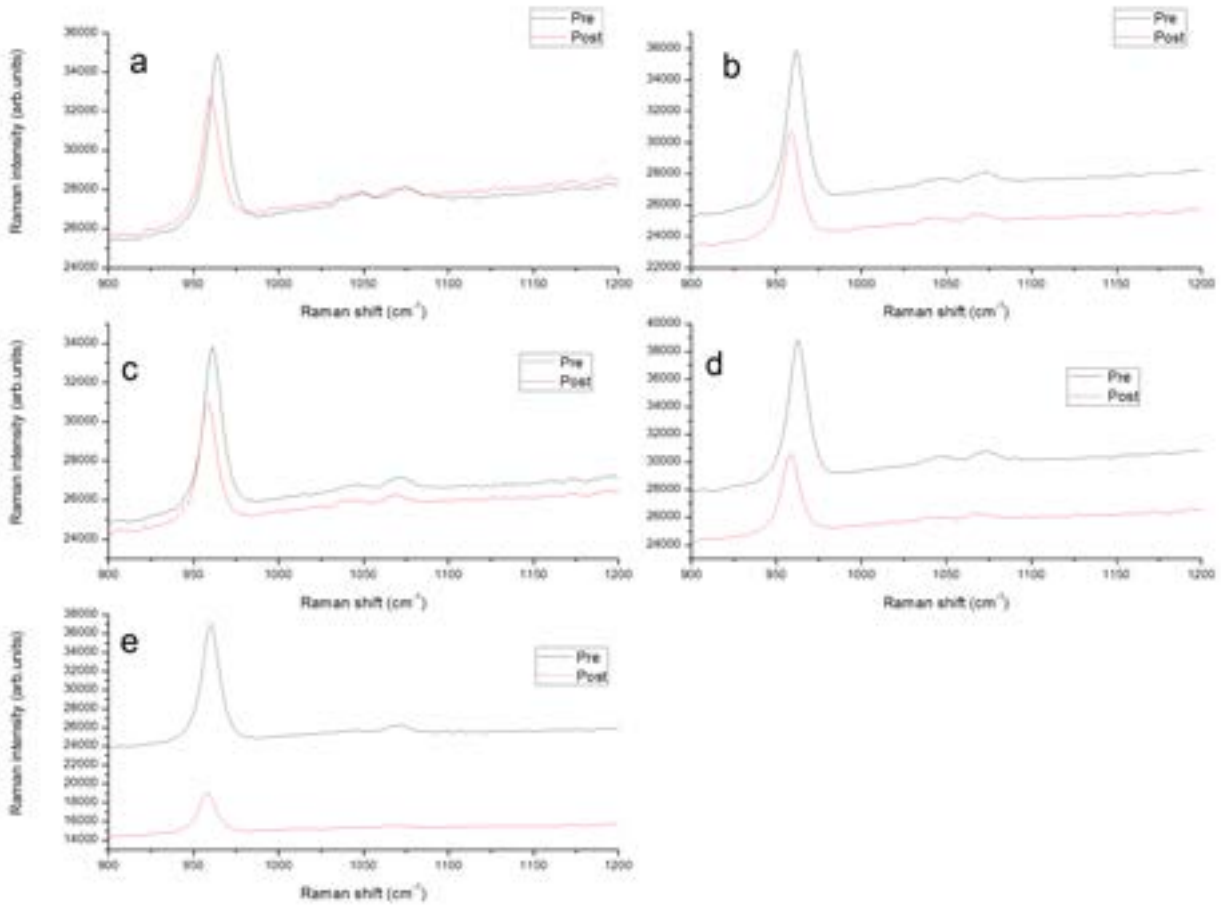

Figure 1. Raman spectroscopy shift for tooth specimens exposed (C) Regular candy (a-e: time interval of exposure).

Hence, there is a need to evaluate clinically, the effect of sour candies and time of exposure on the surface integrity of tooth enamel. This will help formulate a strategy for a better understanding of the oral health impacts on sour candy consumption.

Limitations

The limitation arising from this study is the lack of saliva due to the *in vitro* nature of the study. It is generally acknowledge that intra-oral environment is complex, and therefore, the tested candies may present a different impact on the enamel compared to the static *in vitro* study. Future study will therefore explore the possibility of assessing the erosive effects of sour candies in a more nature *vivo* or *In situ* settings. This would help in understanding the mechanism and associated with enamel dissolution from the consumption of sour candies.

CONCLUSION

In light of the study results, this study suggests that candies, particularly the sour types, present a worrisome impact on the integrity of the tooth structure. It was found that erosive characteristics of the sour candy increase with the duration of exposure time. This is particularly concerning for oral health care provider in the management of tooth erosion amongst children that are a frequent consumer of acidic candies. Consequently, it is recommended that oral care providers advise their patients on the dangers of frequent and prolonged consumption of sour candies.

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Declaration

No conflict of interest declared.

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Botox in periodontics
- Exploring new avenues

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MS Reddy[1], SR Shetty[2], RM Shetty[3], V Vannala[4], SS Khazi[5], ST Mohammed[6]

ABSTRACT

From a periodontal point of view, various factors contribute to facial aesthetics. In the recent past, studies have revealed that excessive gingival display is a factor that influences an individual' smile line. Some literature exists to support that more than excessive gingival display of more than 3mm is considered unaesthetic and termed a 'gummy smile' (GS).

The prevalence of gummy smile' has been 10% and to be more common in females. Gingival hyperplasia altered passive eruption, vertical maxillary excess, and upper-lip hypermobility can all result in excessive gingival display when a patient smile.

To select the correct treatment protocol, accurate diagnosis is essential. Various techniques have used to treat gummy smile which includes surgical and non-surgical methods. Recently nonsurgical method using Botulinum toxin gained polarity considering that the method is minimally invasive.

Keywords

Botulinum toxin, gummy smile, bruxism, dental implants, masseteric Hypertrophy.

Author affiliations:

1. **Manchala S Reddy:** *MDS,* College of Dentistry, Gulf Medical University, Al Jurf, 4184, Ajman. United Arab Emirates.
   ORCID Number: 0000-0002-2441-6479
2. **Shishir R Shetty:** *PhD,* College of Dental Medicine, University of Sharjah, United Arab Emirates.
   ORCID Number: 0000-0002-8097-6024
3. **Raghavendra M Shetty:** *PhD,* College of Dentistry, Ajman University, Ajman. United Arab Emirates.
   ORCID Number: 0000-0003-1209-7295
4. **Venkataramana Vannala:** *PhD,* College of Dentistry, Gulf Medical University, Al Jurf, Ajman. United Arab Emirates.
   ORCID Number: 0000-0001-7075-7883
5. **Shakeel S Khazi:** *MDS,* College of Dentistry, Gulf Medical University, Al Jurf, Ajman. United Arab Emirates.
   ORCID Number: 0000-0001-7018-7550
6. **Shoiab T Mohammed:** *MDS,* College of Dentistry, Gulf Medical University, Al Jurf, 4184, Ajman. United Arab Emirates.
   ORCID Number: 0000-0001-7077-4202

Corresponding author: Manchala S Reddy
College of Dentistry, Gulf Medical University,
Al Jurf, 4184, Ajman. United Arab Emirates.
Email: seshaperio5@gmail.com

Author contributions:

1. **Manchala S Reddy:** Principal author - 20%
2. **Shishir R Shetty:** Second author - 20%
3. **Raghavendra M Shetty:** Third author - 15%
4. **Venkataramana Vannala:** Fourth author - 15%
5. **Shakeel S Khazi:** Fifth author - 15%
6. **Shoiab T Mohammed:** Sixth author - 15%

INTRODUCTION

Over the last decade, facial cosmetic procedures have become more common in dental and periodontal practices. As patient expectations are rising, the demand for facial aesthetics have prompted an evolution in techniques that optimize aesthetics. It is hypothesized that the first impression is the lasting impression and dental beauty is a vital constituent of the impression.

As various emotions can be expressed through a smile, the need for a smile that glows are in demand. Dentofacial harmony relies on three important components teeth, lip, and gingival scaffold that governs the smile as it is a key factor for all expressions. Patient can encounter esthetic and the psychological problems due to gummy smile (GS) as it leads lack of once own self confidence to smile.[1]

Periodontics is a branch of dentistry that not only deals with the tooth supporting structure but also with facial aesthetics and the harmony between the lips, teeth, and gingiva. From a periodontal point of view, various gingival factors contribute to facial aesthetics.[2,3]

Studies support that excessive gingival display have an influence on an individual's smile line.[2] There is a rise in minimally invasive cosmetic procedures and the use of Botox type A (onabotulinumtoxinA) is one such procedure.[4-6]

Botulinum toxin is a lethal, naturally occurring neurotoxin produced by Clostridium botulinum.[7] Presently seven serotypes of botulinum neurotoxin have been identified which include (serotypes A to G).[8] Despite its lethal potential, the protein has other medical benefits.

Currently, there are three different forms of serotypes ie A botulinum toxin (Botox, Dysport, Xeomin) and only one form of type B botulinum toxin (MyoBloc) that have been commercialized for cosmetic and medical procedures.[9]

Botulinum toxin has been used within the medical and dental field for various purposes which include its application to facial esthetics,[8] as an anti-wrinkle agents,[10,11] and in the management of specific lacrimal gland disorders,[12] chronic headaches,[13] children with cerebal palsy,[14] myofunctional pain and occlusal function,[15] bruxisum,[16] dental impants,[17] gummy smile.[18]

The aim of the current review is to discuss the use of botulinum toxin (BTX) as an alternative treatment modality in treating gummy smile and its application in the field of periodontics.

Botox and its applications in periodontics: BTX is used in the field of periodontics for the treatment of conditions, which include a gummy smile that defined as excessive gingival display of gingiva more than 2 mm, bruxism, immediate loading implants, sialorrhea, masseteric hypertrophy and parafunctional habit such as pathologicclenching.[18-20] The etiology for GS was categorized into three factors which include bone gum and muscles.

Bone lead to excess vertical maxilla, the gum in delayed passive dental eruption, and the muscles in hyperfunctioning upper lip elevators.[2]

Diagnosis of gummy smile (GM)

Correct diagnosis of GM is done by identifying the etiology with the help of medical and dental history that provide patient age and eruption stage of dentition along with contributing factors for GM. Followed by periodontal examination to measure width of attached gingiva, probing pocket depth and clinical attachment loss to rule out any pathologic and nonpathological changes in the architecture of the periodontium.

Later analysis of face done to evaluate vertical maxillary excess (VME) by cephalometric analysis. Lip analysis done both in static and dynamic posture to assess lip length, hypermobility, or both. Dentialveolar analysis is done to measure the interlabial gap by analyzing 3D position of the incisors during rest position. 0-4mm is considered normal interlabial gap.[21,22]

Mechanism of Action

BTX inhibits neuromuscular transmission by blocking the extracellular release of acetylcholine thereby inhibiting signals to muscle cells which in turn leads to reduced muscle action or overall lack of muscle contraction as shown below.[19]

BTX type A
↓
Have a heavy chain/light chain
↓
Heavy chain gets attached to the receptors outside the neurons
↓
This leads to internalization of toxin by endocytosis
↓
Once internalization light chain is translocated through the membrane
↓
Then light chain cleaves the SNARE proteins (SNAP25)
↓
This prevents complete assembly of the sympathetic fusion complex
↓
Thereby blocking acetylcholine release into the synaptic cleft
↓
Leading to flaccid paralysis

Factors affecting Botox injections

1. Dosage - Differs among females and males governed by lip muscle volume.[23-25] (Table 1)
2. Precise injection of intramuscular BTX at Yonsei point.[26] (Figure 1)

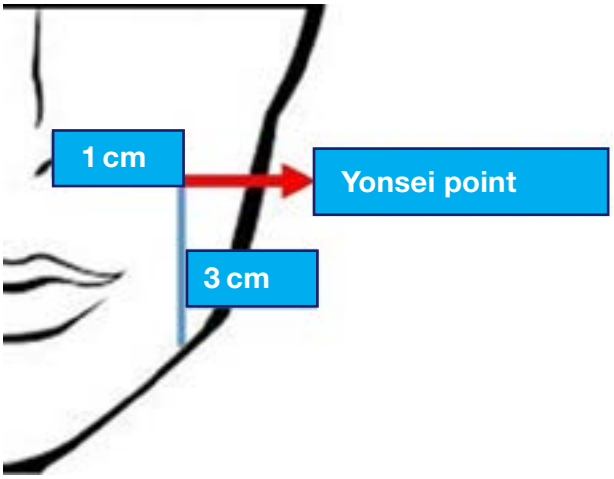

Figure 1. Schematic representation of BTX injection site.

Side effects of Botox injections

Though Botox use is minimally invasive, it still leads to certain side effects. They can be categorized as common side effects, improper injection technique and drug over dosage.[25] Common side effects comprise pain, infection, inflammation, bruising and hematoma formation, loss of muscle strength and, muscle weakness as well as less commonly, nerve palsy.[27]

Improper injection technique could affect the smile symmetry and effect function manifesting as, difficulty in talking, mastication and/or drinking. Drug overdose might lead to a 'loose lip', dropping to beneath the level of the marginal gingiva, affecting teeth visibility during smiling.[28]

Uses of Botox in periodontics

Treatment of gummy smile

'Gummy smile' is a term that refers to excessive maxillary gingival display more than 2 mm during smiling. Its prevalence has been reported as 10% and most common in females aged 20-30 years.[29,30] Etiology for GM vary from short or hyperactive upper lip muscles such as levator labii superioris (LLS), levator labii superioris alaeque nasii (LLAN, levator anguli oris (LAO), depressor septi (DP) and the zygomatic major (ZM) zygomatic minor (Zmi), or other factors such as altered passive eruption of teeth, dentoalveolar extrusion, vertical maxillary excess. Appropriate diagnosis will lead to effective treatment.

GS is diagnosed as low, moderate, and high based amount of gingiva exposed while smiling using Goldstein classification.[25] Various techniques have used to treat gummy smile which includes surgical and non-surgical methods. Recently nonsurgical method using Botulinum toxin gained polarity considering that the method is minimally invasive. BTX is mainly used in patients with hyperactive upper

lip elevator muscles which leads to flaccid paralysis of upper lip thus resulting in the mild gingival display.[26,31] Site of Injection is considered as Yonsei site, which is a core of the triangle constituting LLS, Zmi, LLSAN.[32,33]

(Figure 2) (Table 1)[34-40] Injection of BTX at this point results in muscle paralysis, that intern decrease upper lip lift due to decline in muscles contractability leading to less gingival display while smiling.[25,38,41]

Treatment of Bruxism

The temporalis and masseter muscles are muscles that may be affected in an individual with a bruxism habit. BTX can be used as a virtuous alternative treatment option for bruxism as it reduces the muscle contraction by its inhibitory action on acetylcholine release.[42] It also relaxes temporalis and masseter muscle which provide all the power for bruxism.

It has an edge over other treatment options such as oral splint, behavioral approaches, and muscle relaxants in sleep bruxism cases when compared to conservative apprpoach.[43-44] As its non in vase conservator approach as it reduces tooth wear and protects early implant loss.[44]

In Dental Implantology

There may be therapeutic benefit of BTX administration to the muscles of mastication in patients with dental implants as it may aid favorable osseointegration during the initial phase of healing.[41] Implant failures occur due bruxism or due to excessive functional force. Odds ratio of implant failure has been shown to be 2.71 in bruxism patients vs. non-bruxers. Excessive functional force leads micro-fractures at the bone-implant interface as it exceeds the bone physiologic threshold.[45]

This can be prevented by injection of BTX type A to masticatory muscles. This leads to relaxation of masticatory muscles as well as relief the abnormal forces which results in better implant osseointegration as BTX weakens the muscle for a period of three to four months.[41,46]

Treatment of Sialorrhea

Excessive salivation is termed Sialorrhea. Though various treatment methods are available, of late the use of BTX has gained attention. By injecting BTX into the parotid and submaxillary salivary glands, stimulation of the cholinergic receptors is impeded and thus reducing salivary flow. This technique is simple enough to use in patients with special needs with excessive salivation.47-49

Treatment of Masseteric Hypertrophy

Masseteric hypertrophy usually presents as bilateral soft swelling adjacent to the angle of the mandible, coupled with facial pain. This hypertrophy may manifest as facial disfigurement. Various treatment methods are available interventional technique such as BTX injections has been applied to this condition, with caution.41,50,51

Contraindications

1. Impractical patients.
2. An individual suffering from a neuromuscular malady like (myasthenia gravis, Eaton-Lambert syndrome).
3. Individual hypersensitive to BTX-A or BTX-B.
4. Patients under medication such as aminoglycosides, penicillamine, quinine, and calcium blockers that hamper conduction of neuromuscular impulses.
5. Women who are pregnant or lactating.

CONCLUSION

Botox can be used as an adjunct non-invasive, atraumatic technique to treat patients with a gummy smile, bruxism, drooling saliva, masseteric hypertrophy, pathological clenching and after immediate implant placement.

It is quite a simple procedure that offers an excellent alternative to other procedures with higher morbidity rates. It can meet the expectations of the patient and solve aesthetic problems without surgical intervention. However, every technique has its own added advantages and disadvantages so do with Botox. A word of caution is necessary with its applications as its effects last from weeks

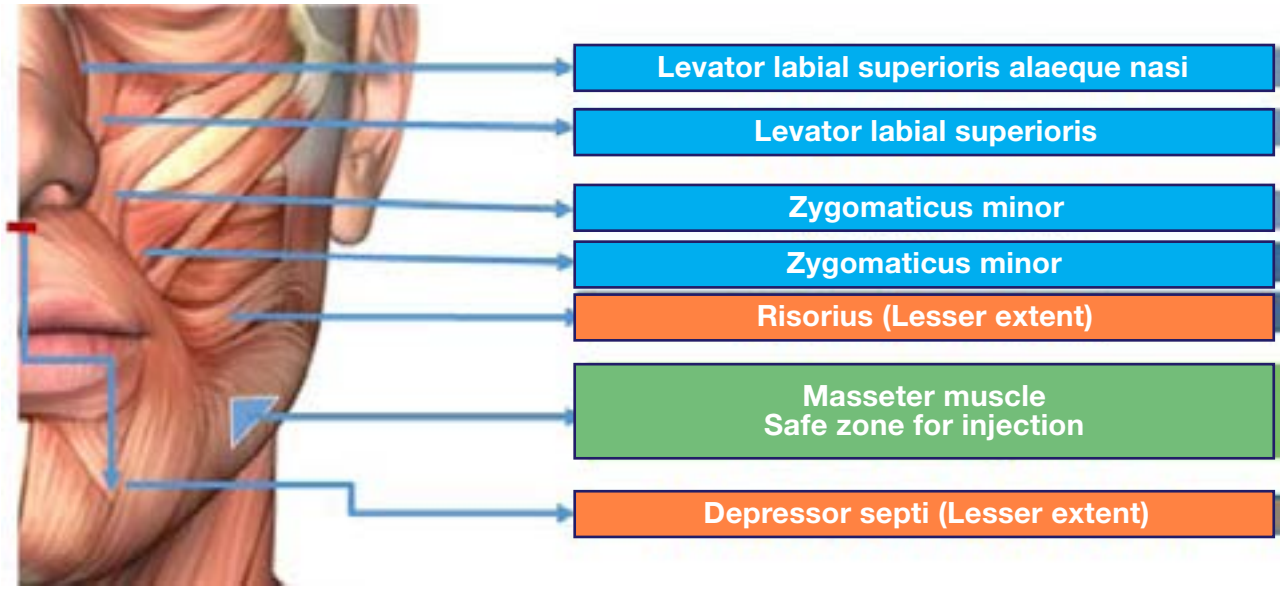

Figure 2. Muscles involved in facial smile and site of injection of BTX .

Table 1. BTX - A used in treating patients with GS and site of injection.

S.No	Authors	Study Type	Condition	Type and dose of Botox	Muscles involved	Adverse effect reported	Results
1	Polo M 2005[28]	Case Report	GS	BTX-A - 0.25 U per muscle bilaterally	LLS, LLSAN, and at the overlap areas of the LLS and Zmi muscles.	Not reported	Authors reported that treatment modality was effective, producing esthetically acceptable smiles.
2	Polo M 2008[34]	Prospective	GS	BTA - A 2.5 UI/0.1 mL	Yonsei point - LLSAN and LLS and the LLS and Zmi	Pain, twitching and headache	Mean gingival display had declined from 5.2 mm (+/-1.4 mm) to 0.09 mm (+/-1.06 mm) in 2 weeks. 24 weeks, average gingival display was 2.9mm.
3	Mazzuco R 2010[35]	Prospective	GS	BTA - A 2.5 UI/0.1 mL	LLSAN and LLS and the LLS and Zmi	Asymmetrical smile	Authors reported general average improvement of 75.09%.
4	Sucupira E 2012[3]	Prospective	GS	BTA - A 3.1 UI/0.1 mL	LLSAN	Not reported	Authors reported average satisfaction level of 9.75 on a 10-point scale.
5	Somaiah S 2013[36]	Prospective	GS	2.5 U R	LLSAN, LLS, Zmi	Not reported	Authors reported decrease in the gingival display (mean 75.09%). Mean gingival display decreased from 4.7 ± 1.06 from the 1st week to 0.95 ± 0.72 in the second week. After 12 weeks it was 3.7 ± 1.16mm
6	Suber JS 2014[4]	Prospective	GS	BTA - A 2 UI/0.1 mL	LLSAN, LLS	Not reported	Authors reported 85% and 83% reduction in gingival display for both central incisor and canines. Central incisor displayed average reduction in GS from 4.89 mm to 0.75 mm and canines from 4.25 mm to 0.74 mm.
7	Al-Fouzan AF 2017[37]	*In vivo* study	GS	Botox type I	LLS, LLSAN	Not reported	Authors reported clear reduction in gingival display after 2 weeks with 96.6% reduction in GS.
8	Pedron IG 2018	Case Report	GS	2 UI/1.7ml	Laterally to each nostril.	Not reported	Authors reported reduction in GS.
9	Araujo JP 2018[38]	Case report	GS	BTX A 2 IU 5 IU	LLS minor zygomaticus bilaterall	Not reported	Authors observed a significant decrease of gingival exposure (4mm) after the period of four injection sessions in an overall interval of 20 months.
10	Mostafa D 2018[18]	Case report	GS	BTX A	4 units were injected on each side of the nasolabial fold, 1 cm lateral and below the nasal ala - Yonsei point	Difficulty in contracting her lips during kissing	Authors observed results that was extremely significant, as the exposed gingival area became 1 mm, However, after 11 weeks, the gingival exposed distance started to increase 1-1.5 mm returning back to its post-surgical appearance after 6 months.
11	Duruel O 2019[39]	Prospective	GS	BTA - A	Yonsei point - LLSAN and LLS and the LLS and Zmi	No complications reported	Authors reported gingival display for each tooth between second premolars was measured less than 3 mm, and the percentage of improvement for each case was calculated 100%.
12	Al Wayli H - 2019[40]	Prospective	GS	(BTX-A)	Yonsei point	Not reported	Authors reported that single dose of BTX-A injected at the Yonsei point was effective in the treatment of GS and achieved better results than multiple injections at various sites.

to months. Controlled use of this therapy is more important rather than its radical use. As the area of periodontics is expanding so boundaries and treatment of periodontal conditions have shifted dramatically the focus of periodontal treatments with the advent of new techniques.

Botulinum toxin has certainly opened the scope of periodontics and is drawing periodontists worldwide to apply it into their clinical use. With proper training, periodontist will be proficient in providing these treatments to patients, to meet both for dental and cosmetic needs.

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Review of the radiographic modalities used during dental implant therapy - A narrative

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KR Beshtawi[1], MT Peck[2], M Chetty[3]

ABSTRACT

The introduction of digital x-ray receivers which replaced conventional films was a significant radiographic development that is commonly used in daily dental practice. Dental implant therapy (DIT) is a sought after dental therapeutic intervention and dental radiography is an essential component contributing to the success of treatment. Dental radiographs taken in daily practice are generally conventional two-dimensional images and/or three-dimensional images. Ideally, the choice of radiographic technique should be determined after a thorough clinical examination and comprehensive consideration of the advantages, indications, and drawbacks.

Digital three-dimensional modalities that have emerged over the last decade have been incorporated into DIT with the assumption that treatment outcomes will be improved. These modalities are constantly being reassessed and improved but there is a paucity of published information regarding the assessment of variables such as dosages and dimensional accuracy, suggesting that further research in these matters is necessary. This is crucial in order to obtain evidence-based information that may influence future radiographic practices.

In this narrative, the authors present the most commonly used dental radiographic modalities currently used in DIT.

Keywords

Dental implant, CBCT, panoramic radiograph, periapical radiograph, radiographic assessment, modalities used.

Author affiliations:

1. **Khaled R Beshtawi:** *B.D.S, MSc, PhD.,* Department of Oral and Maxillofacial Radiology, Dental Faculty, University of the Western Cape, Cape Town, South Africa.
2. **Mogammad T Peck:** *BChD, MSc, MRD, MChD, FDS RCS, PhD, PGDip Med Ed, MBA, MDT FEd,* The City of London Dental School, Southgate College, London, United Kingdom. ORCID Number: 0000-0002-4755-0574
3. **Manogari Chetty:** *BSc, BChD, MChD, PhD.,* Department of Craniofacial Biology, Dental Faculty, University of the Western Cape, Cape Town, South Africa.

Corresponding author: Khaled R Beshtawi
Department of Oral and Maxillofacial Radiology, Dental Faculty, University of the Western Cape, Cape Town, South Africa.
Email: kbeshtawi@uwc.ac.za

Author contributions:

1. **Khaled R Beshtawi:** Conceptualization, analysis, writing: original draft, review and editing - 40%
2. **Mogammad T Peck:** Conceptualization, writing: review and editing, and supervision - 30%
3. **Manogari Chetty:** Conceptualization, writing: review and editing, and supervision - 30%

INTRODUCTION

Dental implant therapy (DIT) is a valuable and highly successful dental intervention that intends to replace missing teeth.[1,2] This therapy has become increasingly popular and substantial numbers of dental implants are placed and restored every year.[3]

The discovery of X-rays in 1895 by Wilhelm Röntgen,[4] has revolutionized dental and medical therapies and imaging during various phases of dental implant therapy has a vital role in its success.[2,5,6] Moreover, the development and transition to digital imaging further enhances the radiographic acumen and offers many advantages such as reduced radiation, immediate acquisition of the radiograph, manipulation of radiographic characteristics like contrast.[4]

Different imaging techniques are used during DIT which have various advantages and disadvantages. The authors present the most common dental radiographic modalities that are currently used during DIT.

CURRENT MAXILLOFACIAL RADIOGRAPHIC TECHNOLOGIES

Various imaging techniques are employed during dental implant therapy including the conventional two-dimensional examinations namely, intraoral periapical, panoramic, and lateral cephalometric radiographs, and the more sophisticated three-dimensional x-ray volumes such as Computed Tomography (CT), Cone-Beam Computed Tomography (CBCT)). Each radiographic technology has indications, advantages, and disadvantages.

Conventional two-dimensional techniques

Intraoral periapical radiography (IPR)

IPR is a widely used imaging technique that exposes a limited number of teeth.[7] In daily practice, these radiographs are used to evaluate the teeth's architecture, position, boundaries, caries detection, and the status of the periapical regions.[7] During implant therapy, the IRPs are popular and indicated for potential implant site assessment and during the post-implant assessment.[8,9]

IPR has multiple advantages during implant therapy and is widely available, cost-effective, provides images with high spatial and contrast resolutions, and allows for the assessment of potential implant site boundaries in the vertical and mesiodistal dimensions.[5,6,9] Although IPR usually produces only nominal geometrical distortion,

this geometrical precision can be vary depending on the patients' compliance and operator skills.[9] Due to the technical challenges, the dimensional accuracy obtained for wide edentulousness bone segments on the IRP can be inconsistent and less reliable.[9] One of the main disadvantages of the technique is the lack of cross-sectional images of the region of interest.[9]

The lack of this information compromises the optimal assessment of the quality and quantity of the bone structures of the potential implant site, moreover, the anatomical relation with the vital structure in the vicinity of the surgical site may not be accurately revealed.[6] The estimated effective dose (ED) for a full mouth survey (18-20 radiographs) is 17 µSv (using a CCD sensor).[10]

Lateral cephalometric radiography (LCR)

LCR is a conventional, two-dimensional radiographic technique that depicts the lateral aspect of the maxillofacial region.[9] This view provides the clinicians with information about the teeth inclination, jaws relationships, and the soft and hard tissue profile of the patient.[11]

Although the use of LCR during DIT is not very popular,[9] it may be indicated in order to plan implant treatments in the edentulous midline areas; as this radiograph provides a cross-sectional view of these anterior regions.[9,11] This view allows a suitable evaluation of the bone quantities in both dimensions (buccolingual and vertical planes of the anterior alveolar ridges), particularly that the LCR has a constant magnification ratio.[9] Disadvantages of this technique during DIT also exist and include the superimposition of the anatomical structures, teeth and bone, lies in the opposite side of the jaw. Uncertain assessment of bone quality and geometric distortion can be encountered if a patient is incorrectly positioned.[5,6,11] The estimated ED is 2-6 µSv.[10]

Orthopantomography or panoramic radiography (PAN)

Panoramic radiographs are a widely used imaging technique that shows a panoramic view of the maxilla and mandible.[10] This modality is unique as only anatomical structures that lie inside a three-dimensional horseshoe-shaped zone, namely the focal trough, are depicted clearly on the radiograph.[10]

Panoramic radiographs are commonly used in various treatment phases during DIT.[9] These radiographs are indicated during the initial evaluation of the potential implant site and the adjacent structures[9,12] and frequently prescribed directly after the surgical placement of several implants and during further follow-up.[9,13]

PAN provides a broad view of the jaws, is relatively less expensive, and is widely available.[6,9,12,14] Nevertheless, these radiographs can be compromised due to geometrical distortion and inherent magnification, reproducibility challenges, uncertainties in bone density assessment, lack of cross-sectional images, inferior resolution compared with intraoral radiographs, and greater technique sensitive.[5,6,9,14]

The head position during the acquisition of these radiographs is critical particularly during implant planning as any minor deviation can result in magnification (15-22%) and image distortion.[6,15] The ED ranges from 9-24 µSv.[10]

Three-dimensional radiographic techniques

Magnetic resonance imaging (MRI)

MRI is a sophisticated imaging technique that uses a non-ionizing magnetic field and radio waves to reconstruct cross-sectional images.[5,16] The use of this modality in dental fields including implant therapies are limited, nonetheless, it can be beneficial to use during the planning phase.[9] During implant therapy, the MRI provides cross-sectional images with high soft-tissue contrast and fewer artifacts that allow the radiographic distinction of neurovascular structures, oral mucosa, and the cortical bone.[5,9,16]

Disadvantages like higher costs, prolonged acquisitions time, challenges of volume interpretation, poor characterization of bone minerals, artifacts from ferromagnetic metals, and contra-indication for certain patients (e.g. cardiac pacemaker, surgical clips *in situ*) contributed to its limited use in DIT.[5,9,16]

Computed tomography (CT)

CT is a three-dimensional imaging technique that was developed by Hounsfield (1972).[17] This modality improved the diagnostic capability of clinicians in medicine and dentistry. Several developments and multiple generations of the modality have evolved during the last decade which has increased the resultant image qualities.[9]

The CT units generate a fan-shaped X-ray beams that are received by multiple detector arrays where the remaining beam intensities are measured.[9,10] These intensity values are incorporated into mathematical algorithms in order to reconstruct multiplanar images.[10]

The use of CT scans during DIT is indicated during the planning phase, in particular, complex cases where the implant site is in close proximity to vital structures and the quantity of the bone is less than optimal. CT scans are also indicated when bone augmentation procedures are needed in sinuses and alveolar ridges, during computer-guided surgeries, and in post-operative complications.[9,13]

CT scans are considered advantageous during implant therapy; as this modality provides three-dimensional multi planar views, accurate dimensions, and optimal resolution of the potential implant site and the surrounding structures.[9,18] CT scans also allow for reliable quantitative and qualitative bone assessment, vital for the success of DIT, before implant surgery.[6,9] The main drawbacks of this technique are the generation of high radiation doses compared with conventional radiographs, less availability, higher cost implications, and possible volume artifacts that may arise from metallic objects and patient movement.[5,9] The estimated ED ranges from 280 to 1410 µSv.[13,19]

Cone beam computed tomography (CBCT)

CBCT is a relatively recent three-dimensional imaging modality that uses a cone-shaped x-ray beam and digital x-ray receivers to reconstruct multiplanar images using special algorithms.[9] The commercial use of this technique

in dentistry began in 1999 in Europe and is now a vastly popular imaging modality in the dental practice.[9]

The use of CBCT scans during DIT is indicated during the planning phase especially complex cases involving proximity of vital structures and low bone quantity, in cases where bone augmentation procedures are needed in sinuses and alveolar ridges, during computer-guided surgeries, and in post-operative complications.[9,13]

The use of the modality during DIT has been growing exponentially as it is readily available and easy to use.[9,20] CBCT's offer fast volumes acquisition (10-80s), lower radiation doses when compared to CT's, high spatial resolution, dimensional accuracy, cheaper unit cost (compared to CT), usually provided with more user-friendly and dentally-oriented software especially when used during implant planning, and the ability to limit the field of view to the region of interest for example just the potential implant site.[9,21,22] It is worth mentioning that variations in some advantages, volume qualities, and radiation doses of different x-ray machines do exist.[20]

CBCT is advantageous in potential implant site assessment as it provides comprehensive anatomical details allowing accurate surgical planning and possible integration with guided surgical techniques.[20]

The drawbacks of CBCT include poor soft-tissue contrast, higher radiation doses when compared with conventional techniques, beam hardening artifact when metallic objects are present, and extra cost implications.[9] The estimated ED ranges from 19-1,073 μSv and is influenced by the field of view and individual units' dose parameters.[10,13]

PHASES OF DENTAL IMPLANT THERAPY WHERE RADIOGRAPHIC MODALITIES ARE INDICATED

The quality and quantity of the anatomical details gathered via dental imaging of the potential implant site influences the success of DIT.[2] Information on the jaw bone anatomy, the quantity and the quality of the alveolar ridge, detection of underlying pathologies, and demarcation of the vital anatomical structure in the vicinity of the implant site can be acquired.[5,6,12,15]

Various factors influence the selection of a suitable imaging technique during DIT. These include the amount of anatomical detail required for the treatment, the amount of information gathered through clinical evaluation of the patient, variations in the clinical judgments among clinicians, radiation concerns, and patient-related factors such as esthetic demands and complications risk assessment.[11,23]

The authors further depict the most common radiographic modalities used in the different stages of DIT.

Radiographic examination: Planning phase

Thorough planning is a prerequisite for successful dental implant treatment and this decreases the risk of potential postoperative complications. During this stage of treatment, the clinician acquires pre-operative vital clinical information on the potential implant site.

Dental imaging plays a major role during this phase as it provides information relating to the potential implant site which includes the alveolar ridge dimensions, the quality of the bone, the spatial relationship of the implant site and other vital structures, determination of the required number of implants, and assessment of the prosthetic needs.[5,6]

Various imaging techniques are being used during this phase including conventional two dimensional to more sophisticated three-dimensional views,[2] nevertheless, an ideal single imaging modality has not been proposed.[9] The choice of the type of radiograph to prescribe is often subjective.[9] Other technical aspects also play a role in this decision and include related costs, accessibility and availability of certain imaging techniques, and radiation exposure levels.[6]

The Intraoral periapical radiographs (IRP) are very commonly used during this phase to initially assess the potential implant sites, appreciation of vital structures, and the discovery of any pathologies in the region of interest.[5,6] The geometrical precision of this type of examination is uncertain and greatly depends on patient compliance and operator skills,[9] making this mode of examination precarious if it is the only radiographical mode of examination. The use of radiographic markers is then recommended to calibrate and enhance the accuracy of measurements particularly in the vertical plane.[9]

Panoramic radiographs are another example of widespread two-dimensional examinations utilized during this phase. Several published reports indicate the beneficial use of panoramic radiographs during implant treatments[24-26] and condone it even as a single radiographic mode of examination.[27] The leading prescription of panoramic examinations during implant therapy is documented in multiple surveys conducted in various geographical parts of the world.[28-32]

These examinations are considered simple, widely available, less costly, and expose the patients to only low radiation doses (compared with CT/CBCT).[24-26] In contrast, single panoramic examinations during this phase are not recommended by other reports[33-35] due to discrepancies found during the assessment of vertical dimensions on the images. The reliability of the dimensions obtained in panoramic radiographs is influenced by the proper patient positioning during the acquisition.[35]

One of the most important pitfalls of planning implant placement on panoramic radiographs is the inconsistency of the vertical and horizontal magnification factors in various segments of the jaw.[35,36] Often, within the domain of the focal trough layer, only certain points are found to reveal distortion-free images of the anatomical structure.[35]

Challenges in the interpretation of volume, increased costs, longer acquisition times, and limited availability hinder the wide use of MRI during implant planning.[9] Although its use is limited, when it is considered for implant planning the use of T1-weighted sequences is recommended.[16]

During the planning of implants on the T1 sequence, the cortical bone presents with low signal i.e. appears dark in contrast to the adjacent spongy bone which appears brighter.[16] MRI is advantageous during treatment planning in cases where the identification of the neurovascular bundles was not precisely identified using other radiographic techniques. This modality offers higher soft-tissue contrast and is capable of portraying the neurovascular bundles within their canals.[16]

During the last decade, CBCT has become increasingly employed during several dental procedures in particular during implant planning, especially in that it exposes the patients to lower radiation doses when compared to the traditional CT.[20,37-39] A survey conducted in the United States (2016) showed that the use of the CBCT was a commonly prescribed method of radiographic investigation during implant planning in academic and private sectors, 49.6% and 59.1% respectively.[40]

The use of CBCT during implant planning is advantageous as this imaging technique delivers distortion and superimposition free multi-planar images that allow for precise assessment and measurements of the potential implant sites.[11,22] Using three-dimensional imaging e.g. CBCT during implant planning can improve the treatment outcomes by enhancing the evaluation of the patient's specific anatomy and reduces the potential of jeopardizing the surrounding structures such as perforation of sinuses and cortical borders and injuring the neurovascular structures during surgery.[9,41,42]

CBCT linear measurements are accurate and reliable during the implant planning stage, confirmed in a recent systemic review.[22] Although submillimeter discrepancies have been reported in many published reports, the authors[22] have provided confirmation that the 2 mm safety margin must be employed, as ranges of over and underestimation of the measurements are also reported.[22]

If computer-guided implant surgery is indicated, three-dimensional examinations such as CBCT and/or CT are mandatory.[43] The surgical and prosthetic phases of implant treatment can be virtually simulated by integrating CBCT and/or CT volumes in the implant planning software.[44] Interactive virtual implant surgery can be simulated and adjusted the quantity of the available bone, circumvent vital structures, and predict prosthetic and esthetic needs.[44,45]

Overview of bone quality

The density of bone at the potential implant site is considered one of the vital factors affecting the success of the treatment.[46-48] Bone quality is not only confined to the density or the mineral content, but includes aspects like the internal architecture of the bone, the alignment of the trabeculae, and matrix-related properties.[21,48]

In CT scans, the tissue densities are represented in Hounsfield units (HU) that are considered a reliable measure to assess the bone density at the candidate implant sites.[5,49-51] In CBCT volumes, the evidence on the reliability of using CBCT gray values for assessment of bone density is uncertain particularly since these values are not absolute as compared to the CT's HU.[21,52,53]

Discrepancies are reported between the CT's HU values and CBCT's gray values[54-57] and on the contrary, other reports[58,59] conclude the opposite. However, the efficacy of using conversion factors to convert the gray values into HU values is also reported.[52,60-62]

Generally, the CBCT gray values are generated in an arbitrary and predetermined fashion by the manufacturers.[52,61] An obstacle is the absence of a standard scaling system among the CBCT manufacturers to standardize these gray values, consequently, the interpretation and comparison of these values acquired from different CBCT units will be difficult and impractical in certain instances.[21,61] The resultant CBCT gray values are greatly influenced by the exposure parameters, machine specifications, and object positions within the x-ray units.[57]

Radiographic examinations: Surgical phase (Intra-operative)

Imaging during this phase of treatment i.e. during and directly after surgery, is indicated to confirm the accurate placement of the implant within the planned surgical site and to ensure an ideal position for the prosthetic restoration to follow.[5,6]
Conventional two-dimensional images are commonly used during this phase such as Periapical and panoramic radiographs, though periapical radiographs are usually considered adequate for this stage.[6,13]

The justification to use CBCT in this phase according to the American Academy of Oral and Maxillofacial Radiology (AAOMR) is confined to cases where there is an alteration in the patient's sensory perception and implant mobility.[9]

Radiographic examinations: Restorative phase

In this stage, the functional restoration is fabricated and integrated with the implant. Periapical radiographs are commonly utilized in this phase and aid in the assessment of the osteointegration of the fixture with the surrounding bone.

This radiograph also contributes as a baseline radiograph, particularly for future bone attachment level comparisons, and the evaluation of the mechanical integration of the different implant components.[63] Moreover, optimum elimination of the peri-implant excess of the cementing material can be confirmed using periapical radiographs; the presence of these materials may result in peri-implant complications.[63,64]

It has also been reported that digital periapical radiographs revealed a greater potential in which misfit of the implant-abutment surface could be detected when compared to the analogue counterparts.[65] In addition, the vertical angle of the x-ray beam is found to significantly influence the radiographic evaluation of the implant components where the misfit may be superimposed depending on the angle of the beam.[63,66]

The attainment of a parallel relationship between the x-ray receiver and the implant long axis inside the bone is vital and can be achieved using x-ray film holder.[63]

Radiographic examinations: Maintenance phase (Post-prosthetic)

This phase commences directly after the completion of the prosthetic phase and lasts throughout life as long as the implant is present in the patient's mouth.[5,6]

Radiographs are indicated in this phase to ensure and monitor peri-implant osteointegration, evaluate the bone levels, and assess the overall status of the implant, restoration, and surrounding periodontium.[5,9]

Conventional two-dimensional imaging techniques like intraoral periapical radiograph (IPR) or panoramic radiographs especially in instances where the patient received multiple implants, are recommended by AAOMR to suffice this phase of treatment.[9] IRP is considered more advantageous to evaluate the peri-implant region compared to CBCT; as the metallic nature of the implant body causes radiographic artifacts (i.e. beam hardening) in the resultant CBCT volumes, which hinders the precise evaluation of the region of interest.[9]

Although in most cases conventional imaging is sufficient for the assessment, in the presence of complications related to the procedure like alteration in the sensation and persistent maxillary sinus infections, the European Association for Osseointegration (E.A.O) justifies using CBCT for further investigation.[13]

From a radiographic viewpoint, a marginal bone loss of 0.9-1.6 mm around the implant during the first year of restoration and less than 0.2 mm in the following successive years is considered a marker of successful treatment.[67-69] A reliable evaluation considers several factors that influence the radiographic assessment of marginal bone attachment levels on IPR.

This includes the position of x-ray receiver, the x-ray beam angulation, the position of the implant in the buccolingual plane, and the possible distortions in the interproximal bony margins on the radiographs.[63,67,70] For that reason, strict compliance to achieve an ideal parallel relationship between the film and the long axis of the implant is mandatory to obtain reliable radiographs.[63,67]

Additionally, a clinician should consider the limitation of two-dimensional radiographs as they do not reveal the status of bony structures that lie in the buccal and lingual/palatal aspect of the implants.[63,67]

EMERGING TECHNOLOGIES

Guided implant surgery (GIS)

Guided implant surgery is a relatively recent method that allows pre-operative virtual simulation of the various phases of dental implant therapy using special software. This simulation is then transferred into the surgical site within the mouth using surgical drilling guides or templates printed in using three-dimensional printers.[43,71]

For this approach to be successful, three-dimensional volumes i.e. CT or CBCT have to be available in order to be integrated into the implant planning software.[43,71]

The inherent artifacts particularly streaking artifact due to densely radiopaque materials may hinder the accurate presentation of the teeth surfaces in these 3D volumes. This issue can be solved by aligning or combining the x-ray volumes with its counterpart intra-oral or a stone model surface scan of the teeth and surrounding oral mucosa.[43,72]

The clinical efficacy of the use of GIS has been reported.[73-77] For optimal success, the virtual planning requires to be accurately transferred to the patient's mouth which ideally should match the planned dimensions.[43] For this reason, ensuring proper alignment in-between 3D volumes and the model scans is indispensable to circumvent inherent imprecision in the resultant surgical template.[43]

DISCUSSION AND CONCLUSION

Various imaging techniques are being used during different phases of dental implant therapy. The selection of a certain radiographic examination should be done after a thorough clinical evaluation of the patient including dental and medical history. Radiographic modalities used during implant therapy vary in the indications, advantages, and disadvantages offered, considering these factors aids in the appropriate selection of the examination that suffices the phase of the treatment.

The three-dimensional views are advantageous during DIT, but still yields a considerable amount of radiation compared to conventional counterparts,[78] which is a concern since this modality is fast becoming a routine and popular procedure in various parts of the world.[38,79] Continuous updates on the most recent radiographic techniques, dimensional accuracy of radiographic modalities, and radiation doses would assist the radiation authorities to establish imaging protocols that ensure clinical efficacy and expose the patient to the least radiation doses.

Declaration of interests

The authors declare no conflict of interest.

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Macrodontia and Dens Invaginatus
- Review of the literature and a case report

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PJ van der Vyver[1], N Potgieter[2], N Moelich[3], Z Vally[4]

ABSTRACT

Disturbances in histodifferentiation and morphodifferentiation may include genetic or environmental factors. These disturbances often lead to dental anomalies. This paper reviews the aetiology, clinical and radiographic appearance, diagnosis and treatment options for macrodontia and dens invaginatus respectively.

A rare case is presented in which the two anomalies occurred directly next to each other in the anterior dentition of a young boy. The diagnostic process and management are reported with a detailed explanation of the use of modern diagnostic aids and equipment.

The procedure of apexification is also described in detail as both anterior teeth were still immature when they turned necrotic. A 2-year follow up reported the successful treatment resolution of infection and associated symptoms, as well as restoration of function and aesthetics.

Keywords

Macrodontia, Dens Invaginatus, Apexification

INTRODUCTION

The aetiology of many dental anomalies remains unknown. Tooth development starts in utero and during embryonic development, when neural crest cells undergo epithelial-mesenchymal transformation. Cells migrate and reorganize away from the neural tube. In the head area, tissue derived from the mesoderm is referred to as ectomesenchyme with neuroectoderm as the origin. From a dental perspective, proper migration of neural crest cells is imperative for the development of the face and teeth.[1]

In addition to the enamel and certain parts of the cementum, neural crest cells are responsible for the formation of all tooth structures. Within the dentinal lamina that has formed, proliferation is constantly occurring, leading to the formation of epithelial buds in the ectomesenchyme. Next, the primary dentition is produced, followed by subsequent permanent dentition.[1,2]

Tooth formation is a complex process with ongoing histodifferentiation and morphodifferentiation. Cells are dependent on each other for this differentiation, and there is space for deviation, leading to disturbance of the tooth germ. Disturbances may include genetic or environmental factors[3] and result in conditions such as microdontia, macrodontia, dens invaginatus, dens evaginatus, Talon's cusp, taurodontism, fusion, gemination, concrescence, dilacerations, enamel pearls and supernumerary teeth.[2]

MACRODONTIA

Macrodontia, also known as megadontia or megalodontia, refers to teeth that are physically larger than normal and could clinically be confused with other conditions such as fusion (two separate tooth germs fusing to form one tooth) and gemination (two teeth that form from one follicle but are not separated).[2,4]

Three different types of macrodontia can be found: true generalized, where many teeth in the mouth are affected (very rare); relative generalized, where all the teeth are affected, and the teeth can either be of normal size in a very small jaw creating the illusion of macrodontia or all the teeth may be slightly enlarged; isolated macrodontia, where only a single tooth is affected (very rare).[5]

The prevalence of macrodontia in permanent dentition is 0.03% to 1.9%, with a higher incidence in males.[3] Macrodontia in the anterior region poses an aesthetic problem for patients, leading to crowding, plaque accumulation, interdigitation and overjet reduction.[6,7]

Treatment is mostly limited to aesthetic desires and may pose challenges during restoration, requiring a multidisciplinary approach, including possible endodontic, periodontic or orthodontic treatment.[6-8] Restoring these teeth is imperative to address the patients' emotional wellbeing.[8] Teeth with macrodontia have wide pulp chambers, limiting

Author affiliations:

1. **Petrus J van der Vyver:** *BChD, PG Dip Dent (Endo), PG Dip Dent (Aesthet Dent), MSc, PhD (Pret),* Department of Odontology, School of Dentistry, University of Pretoria, Pretoria, South Africa. ORCID Number: 0000-0003-1951-6042
2. **Nicoline Potgieter:** *BChD (UP), PG Dip Dent: Endodontics (UP), PG Dip Paedodontics (UWC), MSc Dent (UP),* Head of Division of Paediatric Dentistry, Department of Odontology, School of Dentistry, Faculty of Health Sciences, Pretoria, South-Africa ORCID Number: 0000-0003-4061-3322
3. **Nadine Moelich:** *BchD (UP), PG Dip: Paedodontics (UP), MSc.Dent (UP),* Department of Odontology, School of Dentistry, University of Pretoria, South Africa.
4. **Zunaid Vally:** *BDS, MDent (Prosthodontics) (Wits),* Department of Odontology, School of Dentistry, University of Pretoria, South Africa. ORCID Number: 0000-0002-2718-4706

Corresponding author: Nicoline Potgieter
Department of Odontology, School of Dentistry, Faculty of Health Sciences, PO Box 1266, Pretoria 0001, South-Africa.
Email: nicoline.potgieter@up.ac.za

Author contributions:

1. **Petrus J van der Vyver:** First author, clinical work, write up, editing - 40%
2. **Nicoline Potgieter:** Second author, write up and editing, submission - 30%
3. **Nadine Moelich:** Third author, contributed to write up - 15%
4. **Zunaid Vally:** Fourth author, contributed to editing - 15%

the opportunity to simply grind these teeth smaller because root canal therapy would be imperative.[8]

DENS INVAGINATUS (DI)

DI is a developmental anomaly presenting with complex morphological variations. This anomaly has also been referred to as 'dens in dente', 'dilated composite odontome', 'gestant anomaly' or, simply, an enamel-lined tract.[9,10] DI is the preferred term and has been described as deep infolding of the enamel organ into the dental papilla during tooth development.[11] Starting from the foramen coecum or tip of the cusps, it can extend deep into the root, with or without pulp involvement, sometimes even resulting in a second apical foramen.[11] This anomaly frequently results in early pulp necrosis; therefore managing an open apex can contribute to the complexity of root canal treatment.

Teeth most affected are maxillary lateral incisors with a bilateral occurrence.[11-13] Possible presentation with other anomalies/malformations include microdontia, macrodontia, hypodontia, oligodontia, taurodontism, germination/fusion and/or supernumerary teeth.[11,14-16] The case report in this article demonstrates the coincidence of macrodontia with DI.

The aetiology of DI remains debatable. Theories include buckling of the enamel organ because of growth pressure[12] or focal failure of the growth of the internal enamel epithelium while the surrounding epithelium continues to proliferate and engulf the static area.[17] Another theory is that a distortion and subsequent protrusion of a part of the enamel organ that will lead to the formation of an enamel-lined channel.[18] The 'twin-theory' suggesting a fusion of two tooth germs, rapid proliferation of the internal enamel epithelium, infection and trauma have all been suggested as possible causes of DI.[19-21] Genetic factors cannot be excluded.[14] Therefore, several theories have been postulated but they might be case specific because no single theory has been proven to apply to all cases.

Clinically, the affected teeth may vary in presentation with an increased crown diameter, incisal notching, hypoplasia at the palatal pit, peg or conical morphology, an exaggerated or bifid cingulum, a talon cusp or a deep foramen coecum.[18,22-25] However, the absence of significant clinical signs may often leave DI undiagnosed until symptoms arise from caries or pulpal involvement.[26]

An additional X-ray is advised with a horizontal change of 15 degrees in the mesial direction if DI is suspected.[27] Radiographically, the pulpal morphology of affected teeth usually appear more complex than normal with an alteration in the pulp outline form and associated periapical lesions.[27] The shape of the invagination can vary from a narrow fissure to a tear-shaped loop pointing towards the main body of the pulp.[28,29] The invagination may appear as a radiolucent pocket often, but not always, surrounded by a radiopaque enamel border.[27,30] When the invagination is completely separate from the pulp with its own opening into the periodontal ligament, it can be described as a 'pseudocanal'.[31] Two dimensional radiographs may not provide the true extent of the anomaly, and it is advised to utilize cone beam computed tomography (CBCT) as a diagnostic tool.

DI was first classified by Hallet[32] in 1953, followed by Oehlers[18] in 1957, and remains the most commonly used classification due to its simplicity. Schulze and Brand[33] developed a more detailed classification in 1972 that includes invaginations originating not only in the coecum but also at the incisal edge/tip of a crown. This classification also includes dysmorphic root configurations.

According to the literature, Oehlers' radiographic classification is still used more frequently today than any other.[18] He described three types of DI (**Figure 1**): Type 1: minor invagination limited to the crown, not extending beyond the cemento-enamel junction; Type II: apical extending invagination not limited to the coronal region but extending beyond the cemento-enamel junction, forming a blind sac inside the root that may or may not communicate with the pulp; Type III: severe apical extension of the invagination into the root and exiting into the periodontium.[18] Type III can further be divided into Types III a and b. With Type III a, the invagination extends into the root and exits laterally into the periodontal space; pulpal involvement is unlikely.[34,35] Type III b shows an invagination extending into the root and exiting at the apical foramen into the periodontal space.[34,35] In rare cases of Type III b, the invagination can be outlined by cementum.[35]

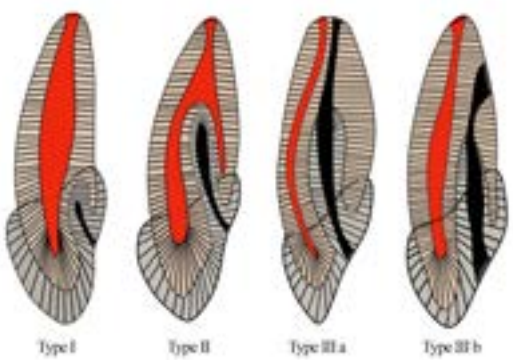

Figure 1. Classification of invaginated teeth by Oehlers.[18]

The choice of treatment is dictated by the anatomic complexity of each individual case. This case report demonstrates the coincidence of macrodontia on a maxillary central incisor and a maxillary lateral incisor with Type II dens invaginatus, both with immature root formation. We aimed to report and discuss the unusual finding and treatment of macrodontia and dens invaginatus of per manent maxillary incisors in the dentition of an 11-year-old male patient.

CASE REPORT

The patient, a healthy 11-year-old male, presented with pain and extreme mobility on his left maxillary central incisor that presented with a macrodontia anomaly (**Figure 2**).

Figure 2. (A) Preoperative clinical photograph of the buccal view of the maxillary central incisors. (B) Intraoral periapical view of the left maxillary central incisor confirming the macrodontia anomaly.

The tooth did not respond to any vitality testing and a periapical radiograph revealed a very large pulp chamber with evidence of periapical pathology around the immature root of the tooth. Vitality testing was normal for the surrounding incisor teeth. Preoperative CBCT confirmed the evidence of periapical pathology around the root of the left maxillary central incisor, a very large pulp chamber and a wide open apex (Figure 3A-C). Additionally, the left and right lateral incisors presented with dens invaginatus and tested vital at the time. The palatal grooves representing the entrance to the invaginations on the lateral incisor were previously sealed

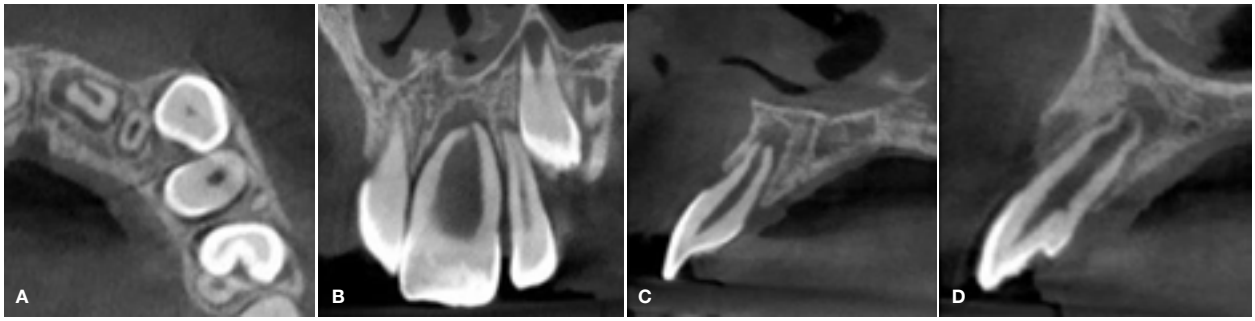

Figure 3. Limited field-of-view CBCT showing: (A) the axial view of the maxillary central incisors demonstrating a periapical lesion around the root tip of the left maxillary central incisor; (B) the coronal view confirming the periapical pathology and incomplete root formation; (C) the sagittal view confirming immature root development with an open apex; and (D) the sagittal view of the vital left lateral incisor presenting with dens invaginatus Type II.

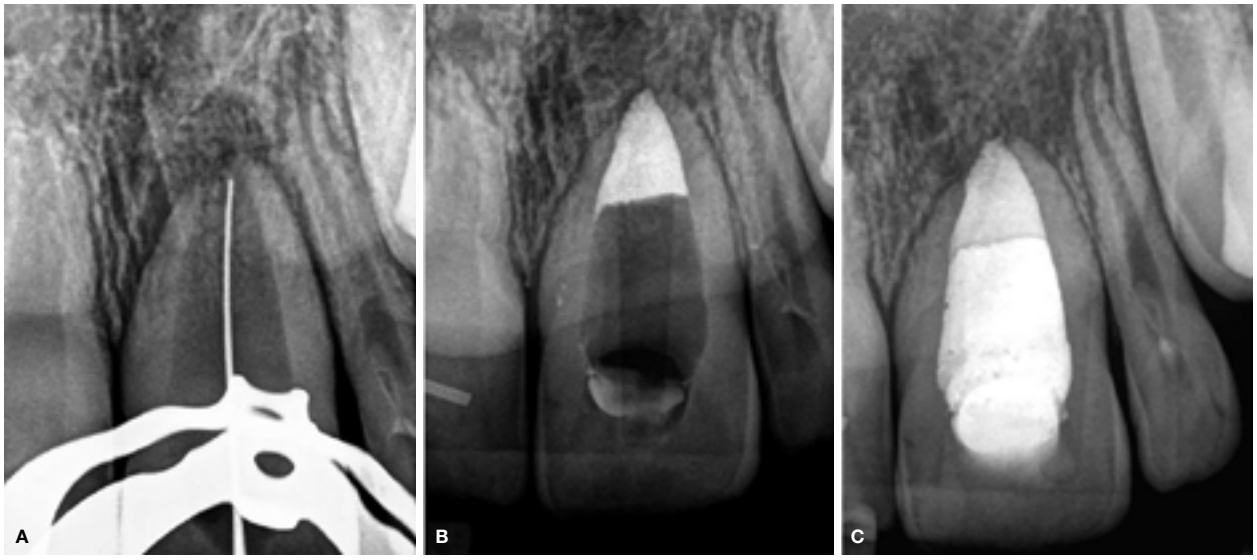

Figure 4. (A) Working length confirmation of the left central incisor on a peri-apical radiograph. Note the size of the root canal compared with that of the size 25 K-File. (B) MTA placed in the lower 4 mm of the maxillary central incisor. (C) Immediate postoperative radiograph after obturation with heated gutta-percha.

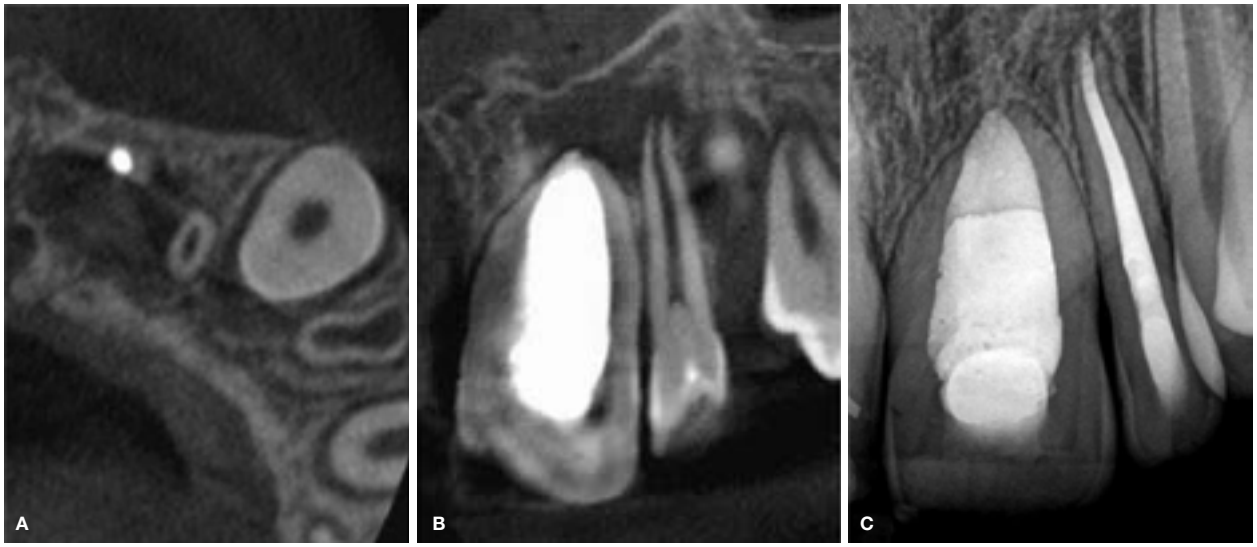

Figure 5. Limited field-of-view CBCT showing: (A) the axial view at the level of the root apex of the left maxillary lateral incisor. Note the large periapical lesion extending mesially to the obturated central incisor; (B) the coronal view confirming the large periapical lesion. (C) Postoperative 2-year follow-up radiograph confirming good healing of the periapical pathology after treatment of both teeth.

with a fissure sealant material. The CBCT scan also showed immature root development of the left lateral incisor presenting with dens invaginatus Type II with a radiolucent area around the root tip, corresponding to the appearance of a dental follicle (Figure 3D).

The tooth was anesthetized and isolated with a rubber dam, working length was determined using a size 25 K-File (Dentsply Sirona, Charlotte, US) with an apex locator and confirmed with a peri-apical radiograph (Figure 4A). An emergency root canal was performed for pain relief. Under microscope magnification (Zumax Medical, Suzhou, China), the pulp chamber was found to be ribbon shaped and very wide mesio-distally. Calcium hydroxide (Calacept; Ultradent, South Jordan, UT, USA) was placed as an intracanal medicament.

At the second visit two weeks later, the tooth was asymptomatic and presented with no mobility. The open apex was closed by packing a 4 mm increment of mineral trioxide aggregate (MTA) (ProRoot MTA; Dentsply Sirona, Charlotte, US) (Figure 4B). The mineral trioxide aggregate was mixed according to the manufacturer's instructions and introduced into the canal with the MAP system (Micro-Apical Placement System) (PD Dental, Vevey, Switzerland) 0.5 mm short of the radiographic apex and condensed by gently packing it with an S-Kondenser (Obtura Spartan Endodontics, Il, USA).

A few days later, after clinical confirmation that the MTA material was properly set (by scratching the surface of the MTA plug that was packed in the apical third of the root canal with a sharp instrument) the remainder of the root canal was obturated with heated gutta-percha delivered from an Obtura II unit (Obtura Spartan, Algonquin, IL). The access cavity was restored with a bulk fill resin (SDR; Dentsply Sirona, Charlotte, US) and composite resin material (Ceram.x Spheretec; Dentsply Sirona, Charlotte, US) (Figure 4C). The patient was scheduled for a follow-up visit to assess healing.

Ten months later, the patient presented for a follow-up visit. Vitality testing was performed again on the adjacent teeth, and the maxillary left lateral incisor was found to be nonvital. The follow-up, low-resolution CBCT revealed a large periapical area around the root tip of the left lateral incisor (Figures 5A-B) that presented with Type II dens invaginatus. The tooth was treated similarly to the central incisor by removing the necrotic pulp tissue and packing MTA close to the open apex of the root canal (using the same technique as described above), followed by obturation with heated gutta-percha.

A two-year, postoperative, periapical follow-up radiograph revealed complete resolution of the periapical pathology (Figure 5C).

DISCUSSION

An early diagnosis is essential for conservative treatment approaches. If no entrance to the invagination can be detected clinically and no signs of periapical pathology are visible clinically or radiographically, only regular follow up is recommended.[11,36] Deep palatal or incisal invaginations or foramina coeca should be sealed before carious destruction can occur.[11,27] If the invagination is larger and pose the possibility to contain caries, it is recommended that the invagination be enlarged and explored.

Caries should be excavated, and the cavity can be decontaminated by applying chlorhexidine or sodium hypochlorite before restoring.[27] Vital pulp therapy may be necessary if small communications arise during cleaning of the invaginations.[27] These minimally invasive preventative treatments should be followed up regularly for the deterioration of sealants and restorations and signs and symptoms of pulp pathosis.

Root canal treatment is indicated in cases where the pulp is irreversibly inflamed or necrotic. When the invagination has a separate apical or lateral foramen, root canal treatment of the invagination can be managed as an additional canal.[23,37] In some cases, eliminate minor forms of invaginations during root canal therapy is possible because they join with the main canal during instrumentation, thereby treating it as a single canal. Another option in larger invaginations is to remove the invagination within the pulp canal as a whole.[24,38] Caries-indicating dye can be used to identify the outline of the dens, which is then troughed around it to loosen it. A tight-fitting file can then be screwed into the dens to aid in removal; however, this technique is not possible in all cases.[38]

The large and irregular volume of the root canal system makes proper shaping and cleaning difficult.[11] Irrigation supported by negative pressure and/or ultrasonic activation is recommended to achieve adequate chemomechanical cleaning of the complex morphology of the root canal system.[38-40] Vertical condensation or thermoplastic filling techniques have been recommended for obturation.[11,37] When pulp necrosis occurs before root-end closure, apexification procedures may be necessary, as demonstrated in this case. Pulp revascularization techniques as treatment options are still being investigated.[38,41,42]

Surgical treatment can be used with root canal therapy and can include debridement, retrograde filling of canals and apicectomy. Surgery is also considered in cases of endodontic failure and in teeth that cannot be treated nonsurgically because of anatomical problems or failure to gain access to all parts of the root canal system.[43-45] Intentional extraction and replantation with retrograde surgery in otherwise hopeless cases has also been suggested. Extraction is only indicated for supernumerary teeth or teeth with severe anatomical irregularities that cannot be treated nonsurgically or by apical surgery.[11]

CONCLUSION

Dental anomalies often occur together, and it is advised to always investigate all teeth if an anomaly is diagnosed. An early diagnosis is essential to allow preventative and minimally invasive treatment approaches.

The complexity of the anomaly, pulp status and amount of tooth structure available will determine the correct choice of treatment. For longterm success, the aim of the management of macrodontia and dens invaginatus anomalies must be to prevent or eliminate infection, maintain tooth structure and restore aesthetics and function.

Declaration of interests

The authors declare no conflict of interest.

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

SADJ March 2021, Vol. 76 No. 2 p96 - p99

Compiled and edited by V Yengopal

1. The effects of Endoseal MTA vs. EndoSequence BC Sealer vs. AH Plus root canal sealer on postoperative pain following single-visit root canal treatment on molar teeth

TU Aslan, H Dönmez Özkan. The effect of two calcium silicate-based and one epoxy resin-based root canal sealer on postoperative pain: a randomized controlled trial. International Endodontic Journal. 2021; 54: 190-7.

INTRODUCTION

Choosing an endodontic sealer for clinical use is a decision that contributes to the long-term success of non-surgical root canal treatment. Sealers are used as a thin tacky paste which function as a lubricant and luting agent during obturation, allowing the core obturation material, such as gutta-percha points or other rigid materials, to slide in and become fixed in the canal.[1]

Sealers can fill voids, lateral canals, and accessory canals where core obturation materials cannot infiltrate. If the sealer does not perform its function, microleakage may cause root canal failure via clinically undetectable passage of bacteria, fluids, molecules or ions between the tooth and restorative material. It has been reported that extrusion of the sealer during root canal filling has cytotoxic effects on periapical tissues, causing periapical inflammation, necrosis and pain.[1]

Endodontic sealers are categorized by composition based on setting reaction and composition: zinc oxide eugenol, salicylate, fatty acid, glass ionomer, silicone, epoxy resin, tricalcium silicate, and methacrylate resin sealer systems.

Aslan & Özkan (2021)[1] reported on a trial that sought to evaluate the effect of two calcium silicate-based root canal sealers, Endoseal MTA and EndoSequence BC Sealer, on postoperative pain following single-visit root canal treatment on molar teeth compared to their epoxy/amine resin-based counterpart AH Plus. The null hypotheses tested in this study were as follows:

1. The type of sealer used would not change the incidence and the intensity of post-treatment endodontic pain
2. The analgesic intake of patients following single-visit root canal treatment would not differ amongst the experimental groups.

MATERIALS AND METHODS

96 patients were included in this trial. Only patients who had mandibular first and second molar teeth diagnosed with asymptomatic irreversible pulpitis due to deep caries were included. The clinical diagnosis of asymptomatic irreversible pulpitis was based on the presence of a deep carious lesion that would cause a large pulp exposure during its removal and in the absence of clinical and radiographic pathosis and symptoms.

Additional identifiers for this diagnosis were that after exposing the pulp, profuse bleeding of the pulp having a thick consistency and an inability to achieve haemostasis within 2-3 min.

Patients were considered for inclusion if they: were between 18-60 years old; had good oral hygiene; had not used any analgesic or antibiotic in the previous 7 days; had a Prolonged positive response to cold test and were patients diagnosed with asymptomatic irreversible pulpitis caused by deep carious lesion on the mandibular first or second molar teeth.

Veerasamy Yengopal: *BChD, BScHons, MChD, PhD*, Community Dentistry Department, School of Oral Health Sciences, University of Witwatersrand, Medical School, no. 7 York Road, Parktown 2193, South Africa.
ORCID Number: 0000-0003-4284-3367
Email: veerasamy.yengopal@wits.ac.za

Patients were excluded if they were medically compromised, had symptomatic or non-vital teeth, had a probing depth of >4 mm on affected teeth, or had an open apex, presence of calcification, or presence of resorption.

All procedures were standardised and performed by two specialists having at least 10 years of clinical experience. Throughout the entire procedure, the operators used dental operating loupes at ×4 magnification. All patients received a single-visit root canal treatment to limit the potential pain-inducing factors that might becaused by multiple visits. During the diagnostic examination, thermal tests and electric pulp tests were performed to determine pulp sensibility.

After the root canal procedure (obturation and irrigation and cleaning and drying out of canal), participants were randomly allocated to a group using a computer algorithm program (n=32). Allocation was done by a trained dental assistant who was blinded to the study procedures to prevent bias.

- Group 1: AH Plus
- Group 2: Endoseal MTA
- Group 3: EndoSequence BC Sealer

After the allocation of patients into the experimental groups, six patients stated that they wanted to withdraw from the study at the beginning of the canal filling process; therefore, they were excluded from the study. Since the remaining 90 patients wished to continue, 30 patients were allocated into each experimental group (n=30). A single tapered gutta-percha cone [Reciproc R25 or Reciproc R40 gutta-percha cones] was adapted to the root canal, and the position of the cone was confirmed with a periapical radiograph. Afterwards, sealer application with suitable paper point cones (1mm shorter than working length) was done as follows: the first paper point was used to apply the sealer, the second one to distribute and the third one used to remove excess sealer.

Following sealer application, the root canal was filled with a single cone placed in the canal. Subsequently, excess gutta-percha cone was removed and the pulp chamber was cleaned. Then, coronal access cavities were restored with a direct adhesive build-up using a composite resin material (Single Bond Universal). Finally, ibuprofen 400mg was prescribed and the patients were recommended to use it only when they encountered severe pain.

After treatment, two forms were given to the participants. The first form designed to record pain levels was based on the Visual Analog Scale (VAS), where VAS pain levels were indicated on the chart by the participants. The value “0” was defined as “no pain,” and ”100” was defined as “unbearable pain".

In the second form, participants were asked to report the frequency of analgesic drug intake. The patients were asked to choose one of the three options: “0: No pain, or pain which does not require the use of analgesics,” “1: Moderate pain which can be well controlled by the use of analgesics and does not affect daily activities or sleep,” “2: Impaired daily activities due to unbearable pain that cannot be controlled by the use of analgesics.”

Participants were asked to complete these two forms at 6, 12, 24 and 48h after treatment and on the 3rd, 4th, 5th, 6th and 7th days. A phone call was made every day for 7 days to obtain information on the postoperative pain and the frequency of analgesic intake. The patients were asked to call the contact number on the form if they encountered severe pain or if they needed to ask any questions regarding the treatment.

RESULTS

The treatments of two patients in the Endoseal MTA group (due to nausea), and four patients in the AH Plus group (one patient due to nausea, two patients due to anxiety, and one patient due to root canal sealer extrusion) could not be completed in a single visit. Thus, they were excluded from the final analysis, that included a total of 84 participants (50 females and 34 males).

Fifty-three of the treated teeth were mandibular first molars and 31 were second molars. The sample comprised 61 teeth with three main root canals, 21 teeth with four and two teeth with two root canals. The total number of the treated mandibular root canals was 271. Depending on the initial root canal size, 42 were prepared up to R40, the rest (229 root canals) were shaped to R25.

There were no significant correlations between age and postoperative pain at each time-point [at 6, 12, 24 and 48h after treatment and on the 3rd, 4th, 5th, 6th and 7th days] ($P>0.05$). There were no significant correlations between gender and postoperative pain at each time-point ($P>0.05$). There were no significant differences amongst the Endoseal MTA, Endosequence BC Sealer and AH Plus groups at any of the assessed time intervals based on VAS scores ($P>0.05$). The most severe postoperative pain scores were recorded 6h after the procedure, with the severity declining significantly after 12h in all the root canal sealer groups ($P<0.05$).

There were no significant differences in the intake analgesic for the Endoseal MTA, Endosequence BC Sealer and AH Plus groups ($P>0.05$). Analgesic intake significantly decreased after 12h in all groups ($P<0.05$).

CONCLUSIONS

The researchers found that Endoseal MTA, Endosequence BC Sealer and AH Plus were not significantly different in terms of the severity of postoperative pain after single-visit root canal treatment on molar teeth.

Implications of practice

The researchers found that Endoseal MTA, Endosequence BC Sealer and AH Plus were not significantly different in terms of the severity of postoperative pain after single-visit root canal treatment on molar teeth.

Reference

3. Aslan TU, Dönmez Özkan H. The effect of two calcium silicate-based and one epoxy resin-based root canal sealer on post operative pain: a randomized controlled trial. International Endodontic Journal. 2021; 54: 190-7.

2. Effect of preoperative oral administration of steroids in comparison to an anti-inflammatory drug on postoperative pain following single-visit root canal treatment - a double-blind, randomized clinical trial

N Suresh, V Nagendrababu, V Koteeswaran, JS Haritha, SD Swetha, A Varghese, V Natanasabapathy. Effect of preoperative oral administration of steroids in comparison to an anti-inflammatory drug on postoperative pain following single-visit root canal treatment - a double-blind, randomized clinical trial. International endodontic journal. 2021; 54: 198-209.

INTRODUCTION

The incidence of postoperative pain following root canal treatment ranges from 25-70% at 24 hours post-treatment Injury to the periapical tissues as a result of canal instrumentation, the extrusion of microorganisms, dentine/pulp debris, and/or medicaments and irrigants have been linked to postoperative pain after single- or multi-visit root canal treatment.

These factors trigger the sequential release of acute inflammatory chemical mediators such as prostaglandins, leukotrienes, bradykinin, serotonin and cytokines that activates and sensitizes the nociceptors that results in a neuronal response that patients perceive as pain.[1]

Use of systemic drugs to reduce the inflammatory reactions with the administration of a single dose of oral premedication has been reported to be effective in reducing postendodontic pain.[1] Prednisolone, a synthetic glucocorticoid; Dexamethasone, a potent anti-inflammatory corticoid, and Piroxicam, a nonsteroidal anti-inflammatory drug of the oxicam class, have all shown efficacy when used for premedication. However few good quality studies exist that have compared these drugs.

Suresh et al (2021)[1] reported on a trial that sought to compare the effect of a single, orally administered preoperative dose, of piroxicam, prednisolone, dexamethasone or a placebo on postoperative pain after single-visit root canal treatment in teeth with symptomatic irreversible pulpitis and symptomatic apical periodontitis. The null hypothesis was that all the premedication drugs tested would have no effect on postoperative pain after single-visit root canal treatment.

MATERIALS AND METHODS

This study was designed as single-centre, multi-arm randomized, placebo-controlled double-blinded trial. A total of 186 patients were screened against the following inclusion criteria: Systemically healthy patients aged between 18 and 60 years with maxillary or mandibular posterior teeth diagnosed with symptomatic irreversible pulpitis and apical periodontitis were included.

Diagnosis was based on clinical and radiograpic examination and pulp sensibility testing. Teeth were included if they had moderate sharp spontaneous pain (preoperative visual analogue scale (VAS) score: ≥4) or pain stimulated with hot or cold with a lingering response even after removal of the stimulus with pain on biting or chewing.

Tenderness to percussion was performed by tapping the teeth with the end of a mirror handle. The teeth with no evidence of periapical changes in radiographs were in cluded. Teeth that were tender on percussion and also exhibited a positive response to electric pulp testing as well as a lingering response of more than 10s to cold test (ethyl chloride spray) were included.

Teeth with crown/root fractures, acute or chronic apical abscess, pulp necrosis, compromised periodontium and open apices were excluded. Patients who could not interpret the VAS, medically compromised patients, pregnant and lactating women were excluded. Patients having history of allergy to local anaesthetic solutions or any of the experimental drugs, on long-term medications that influenced pain threshold, analgesics, steroids and/or antibiotics in the recent past 24 h, were also excluded from the trial. Teeth with necrotic pulps following access cavity preparation were also excluded.

One hundred and eighty-six patients were assessed for eligibility by a post-graduate student based on clinical and radiographic examination and pulp sensibility testing. One hundred and sixty patients satisfied the selection criteria and agreed to participate in the trial and by random sequence generation and allocation concealment, patients were allocated to the 4 invention groups: - Group 1-20 mg oral piroxicam; Group 2-20 mg oral prednisolone; Group 3-4 mg oral dexamethasone; Group 4 - oral placebo (dextrose).

The respective drug inside the sealed envelope was administered to the patients by a nursing assistant not related to the trial 1 h before the clinical procedure. The endodontic procedure was standardised and carried out by calibrated clinicians. The canals were dried with absorbent points and obturated with a corresponding matched taper single cone of gutta-percha and resin sealer (AH Plus). The access cavity was restored with resin composite (FiltekTM Z350 XT universal), and the teeth were relieved out of occlusion.

The primary outcome measure of postoperative pain was assessed immediately after tooth restoration, 6, 12, 24, 48 and 72h using a Visual analogue scale (VAS). The VAS system of pain assessment consisted of a line 10-cm in length with '0' signifying no pain on one end and score '10' representing the worst pain imaginable. Two methods were followed to assess VAS, one was by providing the

patients with a diary to maintain the pain score and secondly the pain score was also assessed using an electronic method through a phone text by a co-investigator at 6, 12, 24, 48 and 72h.

The patients were requested to return at 72h for review and to hand over the pain score diary. The data from both the methods were compared and the one which provided the pain scores at all-the intervals was taken for final analysis. No changes were made to the study outcome after the commencement of the trial. Ibuprofen 400 mg was prescribed as an escape medicine to be taken at a dosage of one tablet for every 6h in unbearable pain situation and these patients were excluded from further analysis.

The incidence of postoperative pain at 6, 12, 24, 48 and 72h was calculated by the presence or absence of pain postoperatively (percentage). The intensity of pain was assessed at 6, 12, 24, 48 and 72h using the mean pain score. The primary outcomes were to assess the incidence and intensity of postoperative pain following single-visit root canal treatment with regard to administration of oral premedication, whereas influence of gender, age and type of tooth, on postoperative pain, were assessed as secondary outcomes.

RESULTS

Single-visit root canal treatment was provided for 96 molars (62 mandibular and 34 maxillary) and 64 premolars (26 mandibular and 38 maxillary) in the study. There was no significant difference in baseline data in terms of age (P=0.06), gender (P=0.663), tooth type (P=0.387) and pre-operative pain (VAS scores) (P=0.728) amongst the intervention groups and placebo. Out of 160 patients enrolled, three patients from the piroxicam premedication group and one from placebo group dropped out from follow-up.

At 6, 12 and 24 h, the percentage of patients who experienced postoperative pain (incidence) after premedication with a single oral dose of piroxicam, prednisolone or dexamethasone was significantly less in comparison to the placebo (P<0.05).

The mean intensity of pain was significantly greater at 6, 12 and 24h in patients who received the placebo in comparison to the other three intervention groups (piroxicam, prednisolone, dexamethasone). However, there were no significant differences amongst the three intervention groups (P>0.05).

The incidence of postoperative pain at 48 and 72h in the piroxicam, prednisolone, dexamethasone and placebo groups was not significantly different (P>0.05). The mean intensity of postoperative pain was not significantly different between any groups at 48 and 72h.

Within the intervention groups, a significant reduction in intensity of preoperative pain occurred at all-time intervals. However, the reduction of pain intensity from 6h up to 72h was not significantly affected amongst the intervention groups. In the placebo group, the intensity of pain started to reduce significantly only after 48h.

Being a male lowered the odds to 0.54, 0.63 and 0.16 times to experience pain at 6, 12 and 24h, respectively, which was not significant. Age and tooth type were not associated with significant change in the incidence of pain at 6, 12 and 24h. The odds of reducing the incidence of postoperative pain with a single-dose premedication with 20mg piroxicam and 4mg dexamethasone were significant when compared to the placebo at 6h (P=0.03 and P=0.005), 12h (P=0.02 and P=0.006) and 24h (P=0.02 and P=0.005).

The number of patients who consumed the escape medicine was 2.7% (1/37), 5% (2/40), 2.5% (1/40) and 15.4% (6/39) amongst the patients who underwent single-visit root canal treatment following premedication with a single dose of piroxicam, prednisolone, dexamethasone and placebo, respectively.

One patient who was premedicated with piroxicam reported gastritis as an adverse effect during the follow-up at 12h. No adverse effects were observed in other groups.

The number of patients who failed to submit the pain score diary was 16.2% (6/37), 27.5% (11/40), 22.5% (9/40) and 15.38% (6/39) amongst the piroxicam, prednisolone, dexamethasone and placebo groups, respectively.

CONCLUSIONS

The researchers concluded that a single dose of oral premedication of 4 mg dexamethasone, 20 mg piroxicam or 20 mg prednisolone reduced the incidence of postoperative pain following single-visit root canal treatment compared to a placebo at 6, 12 and 24 h.

The intensity of the pain was not different between the premedications at any time interval but was significantly less than the placebo. Administering a single-dose premedication of 4mg dexamethasone or 20mg piroxicam improved the postoperative comfort for patients undergoing single-visit root canal treatment and thereby can improve their oral health-related quality of life.

Implications for practice

This trial has provided evidence of the value of oral premedication for patients undergoing a single visit root canal treatment. The three interventions performed were similarly effective.

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CJ Nortjé[1], J Walters[2]

The accompanying clinical image (Figure 1) cropped pantomograph (Figure 2) and CT axial bone window slice (Figure 3) depicts a 22-year-old male with a 5-month history of a persistent facial swelling. He reported no pain with nasal obstruction and difficulty breathing as the only symptoms. What would your provisional diagnosis be?


Fig. 1

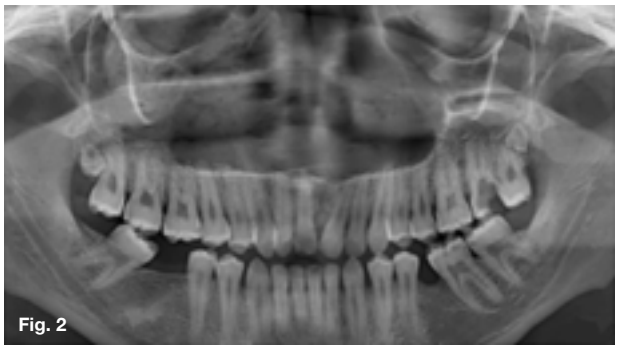
Fig. 2

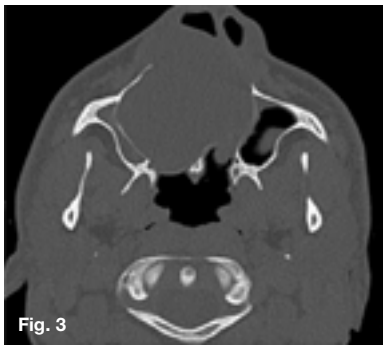
Fig. 3

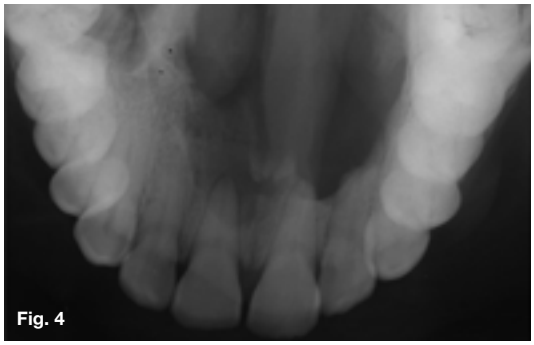
Fig. 4

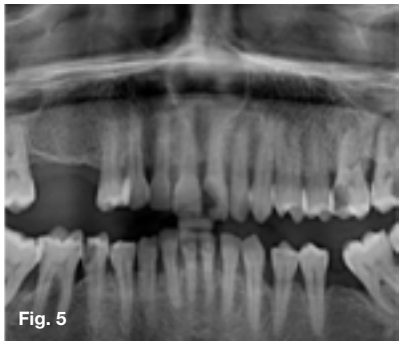
Fig. 5

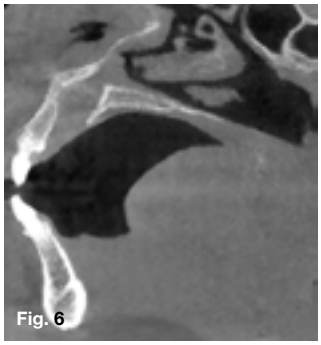
Fig. 6

INTERPRETATION

A bulging swelling was observed in the anterior maxilla that resulted in displacement of nasal features and enlargement of the right nostril. Adjacent teeth tested vital and the contents radiodensity measured approximately 22 Hounsfield units (HU) on CT imaging. An occlusal (Figure 4) cropped pantomograph (Figure 5) and sagittal CBCT slice (Figure 6) depict lesions of a similar origin. Aspiration produced a viscous yellow-brownish fluid, and a biopsy of the cystic-like lining was submitted for analysis. Diagnosis of a 'nasopalatine duct (incisive canal) cyst' was made. The most common non-odontogenic cyst and thought to originate from embryonic epithelial residues. When found in the canal, above mentioned synonymous designations would suffice. When within soft tissue at the foramen 'cyst of the palatine papilla' would be preferred. Frequency has shown to be 1.4% in a population where is of identified non-odontogenic cysts, 73.4% are nasopalatine duct cysts. Predominance is seen between the 3rd and 6th decade with male prevalence at a ratio of 2.5:1. Appearing between the roots of the maxillary central incisors' apical region in the midline of the palate. Radiographic features include a unilocular round or ovoid-shaped homogenous corticated smooth bordered bilateral symmetric cystic-like radiolucency, tooth displacement may be present. Less common features include shape variation, root resorption, asymmetrical bulging, and loss of cortication. Distinguishing from similar appearing lesions or an enlarged incisive foramen may be challenging. Radiographic dimensions of greater than 8 mm in width, 10 mm anteroposterior, and pronounced asymmetrical bulging, with a thin cortical outline suggests further investigation. Extraordinary lesions can result in superior posterior extension into the nasal cavity with erosion of adjacent structures including the hard palate and nasal septum. 3D-imaging can be beneficial should conventional views be inconclusive. Treatment consists of surgical enucleation.

Author affiliations:
1. **Christoffel J Nortjé:** *BChD, PhD, ABOMR, DSc.* Faculty of Dentistry, University of the Western Cape.
   ORCID Number: 0000-0002-9717-5514
2. **Jaco Walters:** *BChD PDD (MFR) PGD (OS) MSc (MFR),* Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, University of the Western Cape, Tygerberg Oral Health Centre, South Africa.
   ORCID Number: 0000-0002-0593-6890

Corresponding author: Jaco Walters
Department of Oral and Maxillofacial Radiology, Faculty of Dentistry, University of the Western Cape, Tygerberg Oral Health Centre, South Africa.
Email: jawalters@uwc.ac.za

Author contributions:
1. **Christoffel J Nortjé:** Principal author - 50%
2. **Jaco Walters:** Second author - 50%

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Dentists and dental technicians
- A united team or uncomfortable alliance?

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LM Sykes[1], H Bernitz[2], LH Becker[3], C Bradfield[4]

INTRODUCTION

The effective practising of dentistry requires that dentists and dental technicians work hand in hand, having mutual respect for each other, while maintaining the highest standards in each of their respective disciplines. From a limited survey of dentists and dental technicians it seems that a small portion of our profession have misinterpreted the concept of "hand in hand" to be one of gross perverse incentives, corruption, collusion and dishonesty.

This article may come as a shock to some and a revelation of what is known to be true to others. The issues discussed have generally been kept as "Dental family secrets", however, the authors believe that these practices need to be uncovered if we want to put an end to this behaviour.

BACKGROUND

The authors became aware that a dental technician's contract was terminated because she refused to carry out work that she felt was unethical. This motivated the authors to probe further into the professional relationship between dentists and dental technicians. While it must be stressed that the majority reported to have good and close working interactions, there were also a number of disquieting revelations, which are presented in this paper.

The purpose of documenting these is not to cause animosity, cast judgement, or forge any division amongst colleagues, but rather to highlight how easily the lure of financial gain can jeopardise honesty and integrity, and compromise the respectability of these professions. In an attempt to maintain objectivity, responses were sought from a range of junior and more experienced dentists and dental technicians, working in both the private and public sectors.

Author affiliations:
1. **Leanne M Sykes:** *BSc, BDS, MDent, Dip Research Ethics (IRENSA); Dip ESMEA (Univ Dundee), DipOdont (Forensic Odontology),* Department of Prosthodontics, School of Dentistry, Faculty of Health Sciences, University of Pretoria, South Africa.
   ORCID Number: 0000-0002-2002-6238
2. **Herman Bernitz:** *BChD, Dip (Odont), MSc, PhD,* Department of Oral Pathology and Oral Biology, School of Dentistry, Faculty of Health Sciences, University of Pretoria, South Africa.
   ORCID Number: 0000-0003-1361-1225
3. **Len H Becker:** *BChD (Pret); HDip Dent (Wits); MchD (Pret); FCD (SA),* Specialist and past consultant to the Department of Prosthodiontics, University of Pretoria, South Africa.
4. **Charles Bradfield:** *B Tech; BChD, PG Dip Dent,* Registrar (Prosthodontics) Department of Prosthodontics, School of Dentistry, Faculty of Health Sciences, University of Pretoria, South Africa.

Corresponding author: Leanne M Sykes
Department of Prosthodontics, School of Dentistry, Faculty of Health Sciences, University of Pretoria, South Africa.
Email: leanne.sykes@up.ac.za

Author contributions:
1. **Leanne M Sykes:** Primary author - 35%
2. **Herman Bernitz:** Second author - 35%
3. **Len Becker:** Third author - 20%
4. **C Bradfield:** Fourth author - 10%

Dental technicians

Dental technicians were asked to respond to the following questions:

"Have you ever been requested by a dentist to:
a). Perform work on bad impressions, or seen evidence of poor clinical work?
b). Carry out procedures that you were unhappy to do?
c). Charge for work not done, or requested to issue fraudulent laboratory accounts?
d). If so, how did you handle the situation?"

Once their laughter had subsided they were more than willing to share their experiences. Their comments are presented verbatim.

Their response to questions a) and b) is reflected in Addendum A.

Addendum A.
1. "It happens on a daily basis."
2. "We get given lousy jobs and told to just make it work."
3. "If we say the work is poor or ask for a new impression, there's always an excuse like – the patient comes from far away; it was a difficult case; the patient is in a hurry and won't come back again; the patient wouldn't open their mouths wide enough, the patient is overseas. The stories are endless."
4. "Their excuses always blame the patient."
5. "You get to know each dentists' shortfalls and then you just work around these."
6. "I often just modify the impressions or the cast myself before I do the work."
7. "You do what you need to do to keep the dentist happy."
8. "I will send it back and ask them to re-do. We are supposed to be a team."
9. "I just try my best. My quality will always be good no matter how poor the foundations are."
10. "If you say it is bad they tell you that you are arrogant and/or lazy."
11. "It's hard. You never see the patient; you just get a slip of paper and an impression. Even if the instructions are unclear you are told just do it and don't bother me."
12. "If there are remakes we are expected to do it for free even though the fault was theirs. How do you prove whose fault it is, that's the question?"
13. "I feel sorry for lots of patients."

Responses to question c) revolved around issues of fraud. Their responses are reflected in Addendum B.

When asked, part d), how they would handle the situation, their response was as reflected in Addendum C.

Addendum B.
1. "A dentist sends me lots of gold inlays but tells me to bill as if they are full crowns."
2. "I've picked up lots of cases of medical aid fraud, but what can I say."
3. "I have been asked to change bills and am very worried that I may get caught."
4. "I've seen evidence of double billing."
5. "I've been asked to issue one lab slip for one patient, but the dentist was actually doing work on 2 patients. The second didn't have a medical aid so they charged for it all on the first ones account. I know because they will ask me to bill for inlays on 11, but I end up making two inlays on different casts and both are on the 11s."
6. "Lots and lots do gold inlays and charge for crowns."
7. "It's not uncommon to charge for things that medical aids WILL pay for when the work is for stuff that is not covered."
In this category there was also reports of suspected over servicing of patients.
8. "I've seen cases where young patients get lots of full crowns but the rest of the teeth are all perfect. I have no X-rays so have no proof that the teeth in question did NOT need these restorations."
9. "Full crowns made for anterior teeth that I think probably could have had veneers. But what do I know, I'm just the technician."
Others said they had witnessed dentists working outside their scope of practice or beyond their levels of expertise, but did not feel that they were in a position to question this.

Addendum C.
1. "The first time it happens you call the guy and tactfully ask if they are sure the impression is correct. They always say yes and tell you to just do it."
2. "If I confront the doctor they will just say do you want my work or not, and if I don't do it Ill lose the job. Probably lose future work as well."
3. "If you refuse to do it they will just take it to someone else."
4. "My boss told me to do it or leave."
5. "When I questioned the dentist, I was told that I can worry about the patient or my money - I must choose."
6. "There's no use reporting it and to who do you report anyway?"
7. "Ethically I would try to find other work, but it's not always easy."
8. "If you confront them they will say you are not the dentist and you didn't see the patient or the tooth or the radiographs so you don't know how bad the mouth actually is."
9. "The primary care giver is the dentist so they must face the patient. If they don't care, then my efforts are not going to change the situation."
10. "If they want to do lousy work, then it's their worry not mine."
11. "Ill just do what they ask for as long as they have signed. Right or wrong."
12. "Small labs are most vulnerable as they can't afford to lose work."
13. It's a small community so if you report or make trouble everyone will know about it and you may as well then close your lab."
14. A final comment was "You can't bite the hand that feeds you."

). Kickbacks

This relates to payment to the dentist by the dental technician in return for having the work referred. The going rate was between 10 and 25% paid back to the dentist for each prescription received. In general amounts were lower (10-15%) for removable dentures and appliances and up to 20-25% for crown and bridge work, and implantology.

The money is usually paid in cash at the end of the month to the dentist. This has led to technicians using cheaper materials or over charging on certain codes to make up for paying these bribes. Items such as 9748, 9741, 9742 (cost of non-precious alloy; chrome cobalt casting alloy and specialized chrome cobalt casting alloy respectively) were often charged twice or three times.

Other examples cited were the use of cheaper/poor quality denture teeth. Instead of using the high grade 3-layered teeth, cheaper and less durable 1 and 2 layered teeth are used while still billing for the more expensive forms. Instead of using the correct Para-Post components, even though this system had been used in the impressions, some fabricate posts and cores for crown and bridge work from Duracast.

). Cash payments

This sometimes occurs in cases of dentists who have registered laboratories. The technician will perform a service and charge the dentist a certain agreed on (reduced) fee, which is paid in cash. Thus there is no record of names, invoices or receipts. The dentist will then claim the full laboratory fee from the medical aid or patient as if the procedure had been done by themselves.

). Purchasing machinery

A technician may purchase equipment such as an intra-oral scanner and make it available to their clients, with the understanding that a certain number of crowns will be done per month.

This can lead to gross over servicing and patient abuse as well as disputes if the promises are not fulfilled (as would be the case with practice restriction due to the Covid-19 lockdown). In addition, with the new technology and use of scanning and digital processing, there is no longer a need to cast models or carry out disinfecting procedures, yet some technicians still charge for this despite it not having been being done.

). Paying kickbacks and declaring them as business expenses.

Technicians offer to pay for a wide range of the dentist's expenses (for example petrol and diesel, new car tyres, municipal fees), and in return the dentist will support them with provision of work.

The technician then uses these account payments as if they were their own and declares them as business expenses. Taking clients on hunting trips or paying for vacations is another common occurrence.

). Manipulating codes to bypass medical aid restrictions

Procedures not covered by medical aids may be carried out (full gold crown) yet charged for as one that is covered (porcelain crown). Despite the obvious fraud, this can also have other serious legal consequences such as in cases of unnatural death where dental identification is needed (see ethics paper SADJ June 2020).[1]

DISCUSSION

Based on the Dental Technicians' responses it seems that they, when requested to complete work on poor impressions, or are faced with other difficult ethical dilemmas, generally have one of four options:

1). Talk to the dentist and if no compromise is reached, risk losing his/her work.
2). Accept the situation and just try and make the best of the task at hand for the sake of the patient and his/her livelihood.
3). Take it upon themselves to adapt or alter the case details before working on it. This may involve adjusting midlines, smile lines, arch forms and occlusal planes in dentures, inserting post dams by "guestimation" onto final casts, ditching around and removing plaster from casts where the impressions were poor, to even altering the actual tooth preparations on the cast in fixed prosthodontics.
4). Commit fraud by charging for work other than that actually performed.

The option of reporting the dentist to the HPCSA or the relevant Medical Aid Societies was never even considered by any of them.

It also raises a number of questions for the dental profession regarding professional education and training. Why do students need five years of training if they are not going to perform the procedures, as they have been taught, once in private practice? How can teaching be improved to ensure students understand the rationale behind, and the relevance of many clinical procedures? Is the teaching in ethics underscored in the clinical wards by the attitude and guidance of teachers, addressing practical situations, or is it too theoretical in nature?

The final assessment on whether the proposed and actual treatment meet the clinical requirements rests with the dentist. The dentist is the guardian, on whom the patient relies for protection of his/her interests. It requires that dentists meet the demands of morality (a personal compass of right and wrong), of ethics (the rules of conduct pertaining to the profession) and of the law (a basic, enforceable standard of behaviour)

Ethics and the legal prescriptions can be taught, but morality is a personal trait. The late Professor Chris Snijman referred to it as "something you get in with your mother's milk"

Prospective dental students are admitted to the undergraduate course based on school leaving results. They are not evaluated for their approach to "ubuntu," nor in respect of their manual dexterity. The outcome of this is that individuals, who do not have the underlying personal characteristics and/or physical abilities to meet the demands of the profession in terms of either/or conduct and/or clinical performance, may be admitted to the study of dentistry. It is then required from their tutors to manage these shortcomings, resulting in them having to spend more time with these students in the clinical wards, to the detriment of others.

Equally, the practice of dentists and technicians demanding or offering kickbacks is illegal, unethical, and brings both parties into disrepute. The Health Profession Council Guidelines for Good Practice are very clear on all of these issues.

HPCSA Booklet 2 deals with Fees and Commissions and talks to the issue of accepting kickbacks. *Rule 7. (1) states: A practitioner shall not accept commission or any material consideration, (monetary or otherwise) from a person or from another practitioner or institution in return for the purchase, sale or supply of any goods, substances or materials used by him or her in the conduct of his or her professional practice;* and 7.*(3) A practitioner shall not offer or accept any payment, benefit or material consideration (monetary or otherwise) which is calculated to induce him or her to act or not to act in a particular way not scientifically, professionally or medically indicated or to under-service, over-service or over-charge patients*.[2]

Furthermore Booklet 11 cautions against accepting commission in return for services. In terms of *Rule 7(3.9.1) Health care practitioners shall not accept commission or any financial gain or other valuable consideration from any person or body or service in return for the purchase, sale or supply of any goods, substances or materials used by the health care professional in his or her practice*.[3]

HPCSA Booklet 11 addresses issues related to the overuse of technology. Whether the dentist is the owner, or user of expensive technology made available by another party, professional ethics dictate that the treatment prescription be based on the diagnosis and the professionally accepted treatment.

CAD/CAM restorations made in order to meet an agreed-upon quantity, is clearly over servicing. HPCSA *Rule 7. (3.1.1) states: Health care practitioners shall not provide a service or perform or direct certain procedures to be performed on a patient that are neither indicated nor scientific or have been shown to be ineffective, harmful or inappropriate through evidence-based review*.[3]

The rule also cautions against preferential use of specific services, if the dentist stands to benefit financially from it, like having an exclusive agreement with one particular dental laboratory, *Rule 7. (3.4) reads: Health care practitioners shall not engage in or advocate the preferential use of any health establishment or medical device or health related service if any financial gain or other valuable consideration is derived from such preferential usage by the health care professional*.[3]

With such clear guidelines it is surprising that both dentists and technicians continue to embark in these illicit practices. Considering that both parties are complicit, the question arises as to who should be penalised if the fraud is discovered?

A further concern is that the dishonesty of one party will by association compromise the integrity of the other if they agree to take part in the scheme. Are we thus turning each other into "offenders and lawbreakers"?

CONCLUSION

The dental fraternity appears to be on a very slippery slope with widespread abuse of authority, blatant disregard for ethical principles, and too many instances of financial dishonesty between and amongst colleagues from two of the closest disciplines. If team members no longer respect each other, are happy to defraud their patients and the medical schemes, and blatantly disregard the law, then what does this say about us as professionals? How can we ever expect our patients and the general public to look up to us, to respect us, or to trust us with their oral health?

We cannot hide behind excuses such as "Everyone else is doing it, so I have no choice but to do the same" or "The medical aids have pushed us into this and we now have to do what we have to do to survive". The onus is on each person to strive to maintain the highest standards of honesty, integrity, and accountability that we all pledged to honour when we took the Hippocratic oath.[4]

Has the time not come for re-assessing admission criteria so that attitude and dexterity can be evaluated before admission to the course in dentistry? Should we not be assessing the course content so that emphasis can be placed on training in clinical procedures that patients can expect dentists to be able to perform?

While not making excuses for unethical behaviour, it must be noted that the impact of the 4th industrial revolution has not only changed the face of dentistry and dental technology, but also the relationship between both parties. Digital technology has resulted in a blurring of boundaries between the clinical and laboratory aspects of many restorative procedures. Now dentists are carrying out work that was previously within the scope of technicians. Perhaps the next paper should investigate issues such as who can bill for what procedures? How much can each party charge? What codes should be used for medical aid purposes? And who carries the final responsibility for the fit and aesthetics at delivery.

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Do the CPD questionnaire on page 105

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.

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CPD questionnaire

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

GENERAL

Examining the effect of exposure time on the erosive potential of sour candy

1. Choose the CORRECT answer.
   When comparing the effects of sour candies and regular candies on teeth enamel, the following demonstrates erosive potential:
   A. Both sour and regular candies
   B. Neither sour nor regular candies
   C. Only sour candies
   D. Only regular candies

2. Choose the CORRECT option.
   Regular candies have a pH of between:
   A. pH 4-6
   B. pH 5-7
   C. pH 2-4
   D. pH 8-10

3. Which is the CORRECT answer? What minerals were lost after 2 hour exposure to both candy solutions?
   A. Calcium and phosphorus
   B. Calcium and iron
   C. Phosphorus and magnesium
   D. None

4. Select the CORRECT answer.
   Enamel dissolution or demineralization occurs at what pH?
   A. Below 5.5*
   B. Above 5.5
   C. Above 6
   D. At pH 6

5. Which of the following options is CORRECT.
   Deionised water was found to be aggressive to the enamel due to the absence of what mineral?
   A. Iron
   B. Copper
   C. Calcium
   D. Lead

Botox in periodontics - Exploring new avenues

6. Choose the CORRECT answer. How many serotypes of botulinum neurotoxin are been identified till date?
   A. Four
   B. Six
   C. Seven
   D. Eight

7. Choose the INCORRECT option. Botox is used all of the following aesthetic procedures except?
   A. Rhinoplasty
   B. Anti-wrinkles
   C. Dental implants
   D. Gummy smile

8. Which of the following is INCORRECT.
   All are side effects of Botox except?
   A. Hematoma
   B. Bleeding
   C. Muscle weakness
   D. Nerve palsy

9. Choose the INCORRECT answer.
   The mechanism of action of Botox does NOT include:
   A. Inhibits neuromuscular transmission
   B. Blocks extracellular release of acetylcholine
   C. Inhibiting signals to muscle cells
   D. Increased muscle action

10. Which of these options is INCORRECT.
    Botox is contraindicated for all patient except?
    A. Pregnant women
    B. Sensitive to BTX-A or BTX-B
    C. Myasthenia gravis
    D. Masseteric Hypertrophy

Review of the radiographic modalities used during dental implant therapy - A narrative

11. Choose the CORRECT answer.
    Which modality to be preferably used for bone density assessment prior to implant therapy?
    A. Panoramic radiograph
    B. Periapical radiograph
    C. CT
    D. CBCT

12. Which of the following is CORRECT.
    All of the followings are advantages of Panoramic radiography except:
    A. Useful for initial implant site assessment
    B. Upper and lower jaws in one single radiograph
    C. Allows the assessment of the crestal and cortical bones in the jaws
    D. Cost-effectiveness
    E. Allows for the assessment of the bone in the third dimension

Macrodontia and Dens Invaginatus - Review of the literature and a case report

13. Select the CORRECT option.
    Of the different types of macrodontia that are found, the most common type is:
    A. true generalized macrodontia
    B. relative generalized macrodontia
    C. macrodantia
    D. true diffused macrodontia

14. Which of the following options is CORRECT.
The option to grind teeth affected by macrodontia smaller, is limited because of the anatomy related to the following:
A. Teeth with macrodontia have wide pulp chambers
B. Pulpal canals of teeth with macrodontia are anastomosed
C. Pulp chambers of teeth with macrodontia are generally obliterated
D. Pulpal pearls are commonly found in the pulp chambers of teeth with macrodontia

15. Choose the CORRECT answer.
Teeth that are most affected by Dens invaginatus (DI) are:
A. Maxillary lateral incisors
B. Mandibulary lateral incisors
C. Maxillary central incisors
D. Mandibulary central incisors

16. Select the CORRECT option.
Absence of significant clinical signs often requires additional x-ray to be taken to confirm the presence of Dens invaginatus (DI). Additional x-ray is advised with:
A. a horizontal change of 30º in the distal direction
B. a horizontal change of 15º in the mesial direction
C. a horizontal change of 15º in the distal direction
D. a horizontal change of 30º in the mesial direction

17. Which of the following options is CORRECT.
According to Oehlers, an invagination that extends into the root and exits laterally into the periodontal space, can be classified as:
A. Type I
B. Type II
C. Type IIIa
D. Type IIIb

Clinical Window: What's new for the clinician?

18. Select the CORRECT option.
In the Aslan and Özkan trial:
A. There were no significant correlations between age and postoperative pain only at 12 and 24h after treatment
B. There were no significant correlations between age and postoperative pain only at 48h and 5 days after treatment
C. There were no significant correlations between age and postoperative pain only at 4 and 7 days after treatment
D. There were no significant correlations between age and postoperative pain at 6, 12, 24 and 48h after treatment and on the 3rd, 4th, 5th, 6th and 7th days

19. Select the CORRECT statement.
In the Suresh et al. trial:
A. The mean intensity of pain was significantly greater at 6, 12 and 24h in patients who received piroxicam when compared to prednisolone
B. The mean intensity of pain was significantly greater at 6, 12 and 24h in patients who received piroxicam in comparison to dexamethasone
C. The mean intensity of pain was significantly greater at 6, 12 and 24h in patients who received prednisolone in comparison to dexamethasone
D. There were no significant differences amongst the three intervention groups as regards the mean intensity of pain at all time points

20. Which of the following statements is CORRECT.
In the Suresh et al. trail:
A. For those that received piroxicam, dexamesthasone or prednisolone, a significant reduction in intensity of preoperative pain occurred at all time intervals
B. For those that received piroxicam, dexamesthasone or prednisolone, a significant reduction in intensity of preoperative pain occurred only 12h after treatment
C. For those that received piroxicam, dexamesthasone or prednisolone, a significant reduction in intensity of preoperative pain occurred only 16h after treatment
D. For those that received piroxicam, dexamesthasone or prednisolone, a significant reduction in intensity of preoperative pain occurred only 4 days after treatment

ETHICS

Dentists and dental technicians - A united team or uncomfortable alliance?

21. Select the CORRECT option.
A technician paying a dentist in return for having the work referred is:
A. a good way to make sure they get enough work each month
B. acceptable as long as both parties agree to the amounts
C. considered a perverse incentive
D. acceptable as neither medical aids or patients are compromised

22. Which of the following is CORRECT.
It is acceptable to dental technicians to save money or increase profits by:
A. using cheaper materials than charged for if they lucky enough to find these
B. using the cheapest denture teeth available but charge the highest price medical aids will cover
C. using their own version of plastic posts as long as they work like the registered systems
D. using cheaper denture teeth if the patient can only afford these and agrees to their use

23. Choose the CORRECT answer.
A technician who has been given work where they think there may be errors should:
A. Save time by adapting or altering the case details before working on it
B. Use their own discretion and adjust things such as midlines, smile lines, arch forms and occlusal planes according to their experience and aesthetic interpretation
C. Ensure they carve in a suitable post dam if it was forgotten by the dentist
D. Send the work back for correction
E. Save time by calling the patient into their laboratories and checking up themselves

24. Which is the CORRECT statement.
Ethically:
A. Deciding whether the proposed treatment meet the clinical requirements rests with the patient
B. The dentist is the guardian, on whom the patient relies for protection of his/her interests
C. The dentist may accept kickbacks if they also give the patients a reduced fee
D. Technicians are not obliged to declare what materials they are using as long as the work is done and fits well
E. The dentist can't be held responsible for irrational decision taken by the patient

25. Select the CORRECT option.
The HPCSA ruling on kickbacks and commission states:
A. a practitioner may accept commission in return for the purchase of goods, as long as they are used by him or her in the conduct of their professional practice
B. a practitioner should rather err on the side of over-servicing in order to avoid dental neglect
C. a practitioner may accept small gifts but not monetary payment in return for referrals of work to technicians
D. Only A and B are correct
E. None of the above are correct

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THE SOUTH AFRICAN DENTAL JOURNAL
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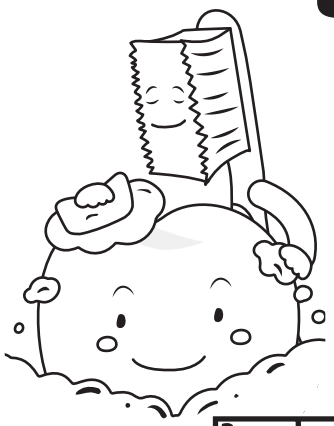
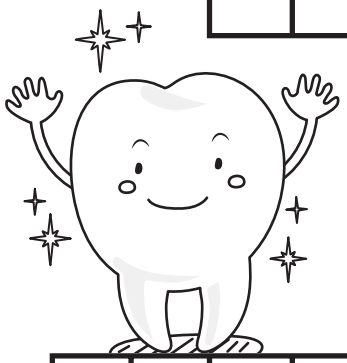
Children's Dental Month

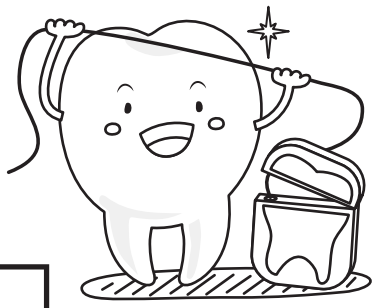
CROSSWORD PUZZLE



WORD BANK

Bacteria	Dentist
Saliva	Baby
Fluoride	Cavity
Toothpaste	Enamel
Floss	X-Ray



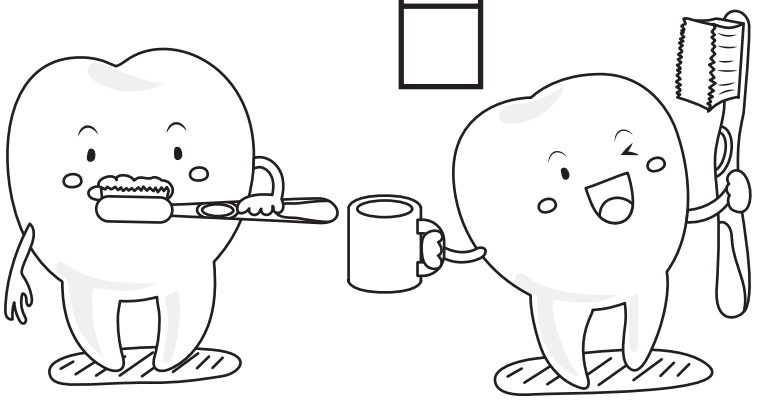


ACROSS

2. Used to clean inbetween your teeth
3. A hole in your tooth is a _____
4. _____ is another word for germs
5. Who you visit to make your teeth healthy
7. Your first set of teeth are _____ teeth
8. Helps protect your teeth from cavities

DOWN

1. What you put on your toothbrush in order to clean your teeth
6. The hard outer layer of your teeth
9. What a dentist uses to inspect teeth
10. _____ helps to break down food while washing your teeth and gums



February is National Children's Dental Health Month | www.sada.co.za, +27 11 484 5288, info@sada.co.za

HEALTHY SMILE TIPS

- Brush your teeth twice a day with a fluoride toothpaste.
- Clean between your teeth daily.
- Eat a healthy diet that limits sugary beverages and snacks.
- See your dentist regularly for prevention and treatment of oral disease.

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