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Victoria Falls

As the mighty Zambezi River with a width of 1,708m crashes over a basalt rock ledge and drops 108 metres down into a powerful whirlpool, it forms the largest sheet of falling water on the planet. Also known as Mosi-oa-Tunya "The Smoke That Thunders" by locals. It provides habitat for several unique species of plants and animals. It is located on the border between Zambia and Zimbabwe and is one of the world's largest waterfalls, the falling water's impressive roar can sometimes be heard from 40 kilometres away. On a wind-free day during high-water season, which runs from about February to July depending on the rain, a dazzling cloud of mist can float high above the Falls. This is truly a magnificent wonder of nature. Scottish missionary David Livingstone identified the falls in 1855, providing the English colonial name of Victoria Falls after Queen Victoria.

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Our Front Cover for this Issue...

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So why did you choose dentistry?

SADJ September 2022, Vol. 77 No. 8 p455

Prof NH Wood - ***BChD, DipOdont(MFP), MDent(OMP), FCD(SA), PhD***

Many dentists have been asked "why did you choose to do dentistry?" in some way or another. We are often presented with some or other cliché such as "I want to help people", but truthfully, the factors that a person may reflect on when considering a profession would include prestige, financial growth and security, job-satisfaction and potential for professional and career development. In all probability the dental profession itself was the best advertisement at the time of deciding on the career path to follow. Yet dentistry is a very specific blend of skills in a healthcare profession that hides a vast ocean of challenges only seen once you enter the profession. Despite this, dentistry draws a large variety of personality types to its practice. There is no doubt that there is a fair amount of artistic ability required in addition to the honing of the clinical acumen.

Dentistry is not free from its stressors and risks. There are many aspects of our work that are considered highly stressful and even dangerous. In terms of the career itself, several studies have identified various factors that negatively impact on the quality of life at work. A recent cross-sectional study that investigated working conditions and the challenges encountered in dentistry found that dentists are at a higher risk for burnout when they have a higher number of patients they perceive as anxious.[1] When work-related stresses are combined with unpleasant experiences, the quality of service-delivery becomes compromised. It is therefore important for the practitioner to be aware of this, and to suitably compensate or compromize where possible. This is for the sake of the immediate dental team members, and the patient's well-being and safety. Interestingly though, the authors of the study confirm the sparsity of research on seemingly challenging patient types for dentists; and how this relates to job satisfaction and work-related outcomes.

The specific and targeted management of anxious patients appears to have a positive effect on the perceived work-related stress of the dental practitioner. This approach must also include communications training. Identifying those anxious patients early on in consultation and implementing suitable protocols to manage these challenging patients has been shown to be valuable in increasing job satisfaction.

In general, the literature indicates that dentists do have a good level of job satisfaction. Whenever dentists report lower job satisfaction levels, it tends to be related to independence, resources, relationships with patients and payment.[2] Dental professionals expressing an intent to change jobs often cite various reasons, however, job satisfaction is seen to hold a high potential to serve as a predictor of actual movement. Similarly, when recruiting and working on retaining dentists, another study suggested that employers must innovate to offer employees acceptable pay, appropriate status or recognition, the realization of personal growth potential, manageable and flexible working hours, and clearly defined career pathways.[3]

If we look back at what it was that influenced this final decision to step into dental school, I am convinced we will hear a wide spectrum of different and interesting stories, but I am also convinced that the bulk of these would not have taken into account the realities spoken of above. Nonetheless, this is certainly one of the most beautiful and fulfilling professions to be a part of, and we should continue to nurture and grow it as a part of our individual legacies. Whatever the time of an individual's decision to become a dentist, or even the initial intent, we will always face the curios interrogation of "Why dentistry?"

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ORAL HEALTH MONTH

SADJ September 2022, Vol. 77 No. 8 p456

Dr Nthabiseng Metsing, Head: Professional Development, SADA

With September being national Oral Health Month in South Africa SADA uses this time as an opportunity to encourage members of the public to pay added attention to their dental routine, particularly as two of the world's most common health problems affect the mouth, namely cavities (dental caries) and gum disease. In continuing with the 2022 World Oral Health Day theme formed by the World Dental Federation "Be Proud of your Mouth" SADA wishes to encourage members of the communities to look after their oral health and be proud of their mouth.

It is reported that in terms of incidence, gum disease (so Gingivitis and Periodontitis) ranks second to the common cold, and it is estimated that 90% of South Africans will experience this problem at some point.

It really is in patients' best interest to practice good oral hygiene. Not only does it ensure a beautiful smile, but it is good for overall health. It is for this reason that we encourage oral health practitioners to take advantage of such months to showcase the importance of good oral health, to their patients and potential patients (society).

In commemorating oral health month SADA embarked on a several activities that were intended to educate members of the public, which included: broadcast interviews, educational social media posts, print media statements, school outreach programs and more.

The radio interviews were on the following radio channels;

13 Sept - Clicks Radio / Dr Kiasha Ariyan (YDC president)
14 Sept - Clicks Radio / Dr Nthabiseng Metsing
21 Sept - Good Hope FM / Dr Esme Sithole (YDC secretary)
25 Sept - Lotus Radio / Dr Robyn Kearney (YDC vice president)
04 Oct – Power FM / Dr Nthabiseng Metsing

The social media posts featured the YDC committee members who recorded short videos for airing, addressing various oral health matters aimed at the members of the public. These were aired on the SADA Facebook page and are also available on the SADA YouTube channel.

Print media statements included a release on 6 September 2022 in which the significance of National Oral Health Month in SA was emphasized. On 14 September 2022 SADA Pretoria branch embarked on an outreach program. Where Dr William D Kearney, President of the Pretoria Branch of SADA, and Dr Robyn Kearney, Vice President of the SADA Young Dentist Council (YDC), took time to perform dental procedures on special needs children and adults.

Woodside Sanctuary were immensely grateful for the assistance together with the team from Centurion Day Hospital for the incredible assistance provided to three of our intellectually incapacitated residents who have experienced dental issues for some time.

The Complexity of Dental Enamel

SADJ September 2022, Vol. 77 No.8 p457 - 458

GH Sperber

Dental enamel constitutes the least quantitative and rarest component of all tissues in the human body but is the most enduring and hardest constituent of ectodermal cellular development. Dental enamel can be a harbinger of history, reflecting the environment during the time it was being formed. Enamel first appeared around 415 million years ago when the suite of genes that encode the proteins required to make enamel appeared in the scales of sarcopterygians.[1]

The vitreous nature of enamel provides its white lucent, iridescent and gleaming appearance as a physically attractive feature of a human smile, but contrarily, it may provide a snarling repulsive warning of a sneer.

The production of enamel by ameloblasts is among the most complex tissues of histogenesis. Amelogenesis is so specialized in its production of enamel that it is not replaceable as enamel in any form of tissue repair. Accordingly, any damage to enamel, be it by acidogenic decay or trauma has become the raison d 'etre for the dental profession in repairing the consequences of enamel loss.

Enamel is an instantaneous fossilized tissue developing in situ in during amelogenesis in living individuals that consequently reflects the environmental and metabolic status of an individual. Any deviation of the genetically determined pathway of enamel formation is permanently imprinted upon the histology of enamel, providing enduring evidence of the dysmorphogenesis. Hence, the genetically determined condition of amelogenesis imperfecta is engrafted upon enamel during its formation and is revealed post-eruption on the teeth exhibiting hypoplasia. Moreover, enamel is unique in both providing information on extant living individuals, and on long-deceased and extinct fossilized species.

Enamel formation

The elaboration of enamel as a complex combination of enamelin, tuftelin, amelotin, ameloblastin, amelogenin, tuftelin interactive protein 11, beta defensin 1, matrix metallopeptidase 20 and enamel structure variables secreted by ameloblasts that take a path from the delicate scalloped amelodentinal junction to the destined cusp tip and down into the crevices of the fissures and along the ultimate enamel margins.[2] The variation of the thickness of enamel at these different locations must presumably be genetically determined by ameloblast viability, diminishing from the peaks of the tooth cusps to the ultimate cessation of amelogenesis at the enamel margins. It would be interesting to investigate the longevity of short-lived marginal ameloblasts if they could be transferred to longer lived cusp tip locations. Is their fate determined by genes or by location?

During amelogenesis, the physical or epigenetic interactions between the inner and outer layers of the enamel organ might determine enamel thickness. The ameloblastin and amelogenin matrix proteins formed during early stages of amelogenesis are removed during maturation by degradation. The accumulated degraded matrix proteins inhibit further ameloblast activity, thereby determining the thickness of deposited enamel. Such interactions may modulate different ameloblast location longevity, and hence, enamel thickness. Ameloblasts located at a molars' highest cusps can produce enamel as thick as 6 mm.

The thickness of dental enamel may act as a proxy for the durability of a tooth and reflect dietary preferences and possibly the lifespan. Enamel thickness has been studied in Plio-Pleistocene hominin mandibular molars, wherein the thick enamel of the robust Australopithecus species decreases in early Homo to that of modern humans.[3] The enamel thickness of Gigantopithecus blacki, over 6 mm in places, was adapted to heavy wear in a way that differed from Pliocene and Pleistocene hominids.[4] G. blacki was adapted to consuming tough fibrous food, and its thick molar enamel allowed for relative longevity.[5] There might be a correlation between molar wear patterns and enamel thickness associated with dietary changes.[6]

Dental Enamel is the hardest tissue in the body that is initiated in a protein gel that is impregnated by nanometer size minerals in a three-dimensional network. The remarkable strength of enamel comes from its ingenious structure that gives it the hardness and toughness to resist the start and spread of cracks. The newly formed enamel matrix is an amorphous calcium phosphate that transforms into apatite crys-

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tals. The unique resilience of enamel to fracturing is due to the misorientations of the nanocrystals within enamel rods to deviate from one another that deflects cracks.[7] The enamel rods or prisms run parallel to one another from the tooth surface to the underlying dentin, but weave and twist as they go by an elegant configuration that confers the significant durability of enamel. The biochemical constitution of enamel is apatite (Ca5(PO4)3(F, Cl, OH) that is constituted of hydroxylapatite, fluorapatite and chlorapatite. Fluorapatite is the least susceptible component to acid disintegration, making it the reason for fluoridation of drinking water to reduce dental decay. The opportunity to regenerate dental enamel has been explored.[8]

Spectroscopic analysis of enamel formed during a period of high radioactivity of 14C isotopes in the atmosphere, as at the time of the Chernobyl explosion, can identify the date of enamel formation. Similarly, the 18C content of dental enamel provides evidence of ingested vegetation during wet or dry periods occurring during amelogenesis. Further, the administration of tetracycline antibiotics during enamel formation is permanently imprinted on teeth, revealed after their eruption.[9]

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Conformity of removable partial denture designs from three laboratories to a set of design principles

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R Daya [1], CP Owen [2]

ABSTRACT

Purpose. The purpose of this study was to assess and to compare the technical quality of removable partial dentures (RPDs) servicing both public and private sectors, in relation to biomechanically acceptable principles.

Materials and Methods

A convenience sample of work carried out in three commercial dental laboratories servicing both the private and government sectors was used to provide a descriptive study of the laboratory stage of fabrication of RPDs over a 3-month period. Prescription sheets, master casts and completed dentures of 114 cases were evaluated and procedural and design-related information data were captured for each case.

Results

The results were disappointing in that not one of the RPDs evaluated conformed to commonly accepted principles. Not one dentist prescribed the design of the denture. Only one cast was surveyed to determine the path of insertion and any undercuts for the placement of clasps, yet 119 clasps were placed. Although 81 rests were used (in only 25 of the dentures), only 11 of those rests were pre-prepared on the teeth. Only 8 of the 95 acrylic-based dentures had any rests, making the remainder entirely mucosa-borne and therefore potentially iatrogenic.

Conclusions

The study suggests that principles of RPD design taught during undergraduate training are not being adequately practised in both private and public sectors; and if practised the RPDs are not designed, nor constructed to requirements guided by design principles. Further training of dental technicians and clinicians is clearly indicated, and consideration should be given to a system of clinical audit to identify and prevent the malpractice observed in this study. In addition, ethical and legal guidelines emphasising the roles of clinicians and technicians in the prescription and design of RPDs in South Africa should be developed; and the mandatory comprehensive completion of laboratory work authorisation forms by dental clinicians should be considered.

Keywords: removable partial dentures; design principles.

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Author contributions:

1. R Daya: 70%
2. CP Owen: 30%

INTRODUCTION

In developing countries, increasing numbers of patients are seeking treatment for partial tooth loss.[1] Possible treatment options include removable partial dentures (RPDs), fixed partial dentures, and implant-supported prostheses. As technology and materials advance, treatment options such as implants and fixed prostheses have increased, but their costs are high, making them unaffordable to most patients. Conventional acrylic resin or metal framework based RPDs remain the most cost effective option for the majority of patients. [2,3]

RPD design principles have evolved since 1711, when partial dentures were first carved from a block of bone to replace missing teeth.[4] As the years progressed, with the aid of technology, as well as observations with regards to outcomes, RPD designs have changed considerably. Designing RPDs may pose a challenge, as it has been estimated that there are 65,534 possible presentations of partial edentulism for each dental arch, if the only variable accounted for is the presence or absence of teeth. [5] There appears to be no single universally used set of guidelines or principles for designing RPDs, [6,7] although a study conducted in the UK demonstrated that there was general consensus amongst a majority of prosthodontic specialists for a number of principles.[8] A local study[9] used designs agreed to by two prosthodontists to enable comparisons with actual designs observed in commercial laboratories.

A questionnaire study on RPD designs in South Africa reported a distinct disparity between principles and methods taught and practises routinely applied after graduation. [10] The study reported that 82% of dentists instructed the laboratory technicians to design the RPD; casts were not surveyed by 64% of dentists, and 55% were not mounted on an articulator. A more recent local study of RPDs produced in three commercial laboratories found that 55% of the designs had no rests; 65% of the acrylic RPDs had no rests and 85%

had no clasps; and metal RPDS had more clasps than necessary. [9]

To date, no published studies have been carried out in South Africa that have compared the designs observed in commercial laboratories to a set of design principles, nor have any comparisons been made between RPDs made for the private or public sectors. [11,12] The aim of this study was therefore to assess the designs of RPDs being produced in three commercial laboratories supplying both the public and private sectors against a set of design principles derived from the literature.

MATERIALS AND METHODS

This was a cross sectional, descriptive study conducted on RPDs during the laboratory stage of fabrication, using a convenience sample of work carried out in three dental laboratories in one district (Ekurhuleni, Gauteng province) for both private and public sectors over 3 months. All acrylic and metal based RPDs were included.

Ethical clearances was obtained from the Ekurhuleni Ethics Committee and the Human Research Ethics Committee of the University (No. M190314). Prior to delivery, each RPD prescription sheet, master cast and final denture was digitally photographed by the dental technicians in a way that allowed the number of existing teeth, the class of partial edentulism, support and retentive components to be identified. In addition, the technicians participating in the study were asked to record a variety of technical aspects of the RPDs: the choice of primary impression materials used, whether special trays were requested, materials used in secondary impressions, use of occlusion rims, types of articulators requested / type of articulators available, try-in procedures and if any dentures were sent back to the lab post-recall for adjustments to be made. A separate column for design and surveying was also completed by the technician. Where possible, at the master cast and prior to delivery stages, close-up photographs were taken by RD.

The photographic records of the casts were then examined and any additional aspects that may have been missed were recorded. They were also examined by an experienced prosthodontist in order to assess/verify technical quality, using the selected design principles. In the event that there was any disagreement in interpreting the images and data capture sheet, an additional prosthodontist assessed the data.

The design principles were derived from a number of sources. [6,-9,13-29] These were:

- Evidence of casts having been surveyed by the dentists and/or dental technicians;
- The presence of articulated diagnostic casts;
- Written or verbal technical instructions given to the technician;
- Provision of denture design drawings by dentists and/or dental technicians;
- The presence or absence of tooth support in the form of rests in the final denture;
- The presence or absence of prepared rest seats on the master casts;
- The presence or absence of clasps in the final denture; and
- The presence or absence of prepared tooth guide planes on the master cast.

A brief explanation for these is as follows:

Surveying and design by the clinician: the design of the RPD is the responsibility of the dentist and a dental surveyor is necessary in order to determine the path of insertion, height of the contour line and to measure undercuts for clasp design. [6,25,29] Diagrammatic and written instructions should include framework design and saddle area extensions, occlusal rests, direct and indirect retention and reciprocation. [30] If wrought wire is to be used for clasps the dimensions of the wire and the depth of undercut in which the clasp should rest should be indicated as well. [29,31]

Importance of articulated diagnostic casts: Articulated diagnostic casts aid in assessing spatial requirements of the dentures when placing rests and designing the framework, ensuring no unplanned occlusal vertical dimension increase occurs. [21]

Tooth support: The purpose of a rest seat preparation is to direct forces axially along the tooth, [23,29] to prevent movement of the denture in an occlusal direction, reducing trauma to the mucosa, and distributing occlusal forces. Rests should be prepared on the occlusal surface of posterior teeth, or on the cingulum area of anterior teeth by a clinician before recording a secondary impression. Rest seat design will vary according to the denture base material (metal or acrylic) or the component used (such as half-round wire for acrylic-based RPDs). [29] Patients who had adequate and sufficient rest seats, were overall more satisfied with their dentures than those whose dentures had inadequate support; [26] and adequate support was one of the few criteria that correlated with successful wearing of mandibular Kennedy Class I RPDs. [32]

Clasps: Clasps should be flexible enough to allow the RPD to be repeatedly seated and removed without permanently deforming the clasp and without damaging the tooth. [29,31,33-37] Although clasps aid in retention, they should not be considered the prime objective of the design. Well adapted and extended denture bases, accurate framework fit, and properly prepared guide planes positively influence RPD retention independently or in combination with clasps. [6,28]

Guide planes and guiding surfaces: The guide plane on the prepared surface of a tooth adjacent to an edentulous saddle, and the guiding surface of the denture provide guide plane retention, by increasing frictional resistance, limiting the path of insertion/removal. In addition they provide stabilisation against horizontal rotation and help to eliminate food traps between the abutment teeth and RPD components. [16,23,28]

Apart from these design principles, there are other factors that contribute to the successful use of RPDs.

Designs should incorporate minimal gingival coverage by major connector components and elimination of redundant components without compromising biomechanical requirements. [7,14,15] In addition, it is not always clear as to what features correlate with patient satisfaction. Frank et al (2000) [32] reported that patients were most dissatisfied with ill fit of partial dentures (76%), followed by iatrogenic damage caused by the partial denture (63%), but found no statistical correlation with rest form, base extension, force control, framework fit, base support, occlusion, stress distribution and retention. However, gingival inflammation was twice as likely when rest seats lacked positive preparation form, the base was under-extended, insufficient rests were placed adjacent to a distal extension, and there was poor fit of the framework.

RESULTS

Types of dentures and sector

There were 114 removable partial dentures recorded, 79 of which originated from the private sector, and 35 from government clinics (Table 1).

Table 1. Numbers and types of RPDs and their origin. Mand = mandibular; Max = maxillary.

PRIVATE				GOVERNMENT			
METAL-BASED		ACRYLIC-BASED		METAL-BASED		ACRYLIC-BASED	
Mand	Max	Mand	Max	Mand	Max	Mand	Max
14	5	14	46	0	0	15	20
19		60				35	

Extent to which the RPDs met minimal principles of design

1. *Evidence of the casts having been surveyed by the dentists and/or dental technicians.* Only one case had been surveyed by one dentist, but the remaining 113 cases had no evidence of having been surveyed at all.
2. *The presence of articulated diagnostic casts.* No articulated diagnostic casts were found.
3. *Written or verbal technical instructions given to the technician.* The laboratories reported 3 cases where they had received verbal instructions from the dentists, 1 from the private sector for a maxillary metal-based RPD, and 2 from the government sector, for a maxillary and a mandibular acrylic-based RPD. Written instructions comprised the completion of a form supplied by the laboratories and were absent in only 6 cases. However, none of the completed forms contained any design instructions.
4. *Provision of denture design drawings by dentists and/or dental technicians*. No cases had any drawings by either the dentists or the technicians.
5. *The presence or absence of rests in the final denture.* None of the dentists had specifically requested rests to be included in the design and the decision for their placement was entirely left to the technician's discretion. The type of rest (anterior or posterior) was not recorded, but 25 of the RPDs did have rests, 17 metal-based and 5 acrylic-based dentures for the private sector and 3 acrylic-based dentures for the government sector.
6. *The presence or absence of prepared rest seats on the master casts.* Four of the casts had evidence of prepared rests on the teeth, 3 metal-based dentures from the private sector and 1 acrylic-based denture from the government sector.
7. *The presence or absence of clasps in the final denture.* Despite there being no designs from the dentists, 54 (47%) of the dentures did have clasps, 40 for the private sector and 14 for the government sector. Of these, 19 dentures were metal-based and 35 acrylic-based. The types of clasps were not recorded other than to note that when a wrought wire clasp was used, the laboratories used a variety of stainless steel clasp of diameters from 0.7 mm to 1.0 mm.
8. *The presence or absence of guide planes on the master cast.* No evidence could be found of any prepared guide planes on the teeth on any of the casts.

Design Principles Met

The most number of design principles met was 3, but that was only in 3 of the dentures out of 114. Twenty three (20%) met 2 principles and 28 (25%) met one. This meant that 54 (47%) did not conform to any of the principles.

DISCUSSION

Removable partial dentures are a viable and cost effective treatment option that can improve the oral-health related quality of life of partially dentate patients, particularly in developing countries, [38] as well as in underserved communities in developed countries. [39] In a South African study, patients reported an improved function, satisfaction and oral health-related quality of life after prosthetic treatment with RPDs. [40]

Rehabilitation of the partially dentate patient requires the clinician to be cognisant of mechanical and biological factors. A biologically acceptable design must take into account factors such as the periodontal condition, number and status of remaining teeth, the nature of the opposing teeth (artificial vs natural), hygienic principles and aesthetics. An ideal RPD is customised for the patient, integrating the clinical findings into a design that widely distributes the occlusal load to include tooth and mucosal support when necessary, with the teeth providing most of the support. Retention from active elements such as clasps and passive elements such as guide planes/guiding surfaces contribute to the overall retention and stability of the RPD. Eliminating redundant components and covering excessive mucosa should always be avoided, and in so doing optimal hygienic principles are incorporated into the RPD and the design is thus simplified.[1] Lower failure rates have been observed when the emphasis on biologically acceptable designs, regular maintenance visits and oral hygiene education was reinforced. [15,41]

This study evaluated the design of removable partial dentures fabricated within three dental laboratories serving the private and public sectors, in Ekurhuleni, South Africa, and using a set of principles derived from the literature. The results revealed that not one of the RPDs evaluated conformed to these principles.

The maximum number of principles encountered in the designs was 3, and only for 3 of the dentures. Almost half (47%) showed no conformity to any of the principles. Not one dentist prescribed the design of the denture. Only one cast was surveyed to determine the path of insertion and any undercuts for the placement of clasps, yet 119 clasps were placed, which implies that they were either placed in the wrong undercut or not in any undercut at all. Although 81 rests were used (in only 25 of the dentures), only 11 of those rests were pre-prepared on the teeth. Only 8 of the 95 acrylic-based dentures had any rests, making the remainder entirely mucosa-borne and therefore potentially iatrogenic.

Such findings, although tantamount to malpractice on the part of both the dentists and the technicians, are sadly not unique. For example, a variety of studies have reported some similar findings: more than 88% of dental laboratories reported that the dentist's communication to them was lacking and that the majority (77.9%) of RPDs were designed by the technicians and not the dentists; [42] 51% of RPD casts were submitted to laboratories without specifying the design or providing written instructions;[38] more than 80% of dentists communicated through generic laboratory scripts only, with 90% rarely or never giving additional details regarding RDP design;[43] and only 46% of laboratory technicians indicated prescriptions were completed accurately. [44]

Mandatory comprehensive completion of laboratory work authorisation forms by dental clinicians is required, prior to RPD fabrication in the United States. The laboratory script is considered a legal document, and is duplicated and included in patient records. [45] Similar legal and ethical guidelines have been included in Medical Devices Directive (European Union) and the British Society for the Study of Prosthetic Dentistry. [43] No such prescripts have been published in South Africa.

The finding here that all the government clinic RPDs were acrylic-based is probably because in the public sector costs are generally kept as low as possible so metal-based RPDs are not routinely made, but the majority of RPDs from the private sector were also acrylic-based. There is no doubt that these are a more cost-effective option, but nevertheless there is no excuse for not providing at least tooth support for these dentures.

Apart from the lack of tooth support, only one cast was surveyed, by one of the private dentists. Not one of the technicians reported surveying a cast, making it impossible that such aspects as the path of insertion, undercut identification and measurement, hard and soft tissue analysis, guide plane analysis and so on can be carried out, leading to potentially iatrogenic consequences. It has been reported that there may be a belief by dentists that the technician has more experience and dentists elect to delegate this responsibility but that this is unethical, as the diagnosis, prognosis and treatment planning are the responsibility of the dentist. [29,38]

A further example of the malpractice observed in this study is the placement of clasps. A recent study has pointed out the necessity to provide the correct material and form relative to the curvature of the tooth, the length of the clasp, and the undercut present, yet none of these appear to have been considered in this study, as inferred from the lack of surveying. [31] It has also been pointed out that guide plane retention especially in acrylic-based RPDs may be sufficient if carried out correctly to obviate the need for clasps. [28] Not one of the RPDs evaluated in this study showed any evidence of this having even been considered.

LIMITATIONS

There were some limitations to this study: only conformity to design principles was recorded, and not every aspect of design so that no analysis of the overall design could be carried out. It was not possible to follow up the dentures to see if in fact the patients for whom they were intended were wearing, and using them. Although the standards investigated are derived from an extensive literature, there is no universally accepted set of standards.

CONCLUSION

Within the limitations of this study, it can be concluded that none of the participating clinicians and technicians adhered to principles of partial denture design, even though these are extensively taught and adequately practised during undergraduate training.

The RPDs evaluated were neither designed nor constructed to satisfy the principles of partial denture design, and the majority of dentures ae likely to be potentially iatrogenic. There is therefore a clear need for further education and training for both dentists and dental technicians and eventually for a system of clinical audit to be put into place to identify and prevent the malpractice observed in this study, as well as ethical and legal guidelines emphasising the roles of clinicians and technicians in the prescription and design of RPDs in South Africa. Finally, the mandatory comprehensive completion of laboratory work authorisation forms by dental clinicians should be considered.

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The search for a healthy sugar substitute in aid to lower the incidence of Early Childhood Caries: a comparison of sucrose, xylitol, erythritol and stevia

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ABSTRACT

Aim

A pursuit to find a healthy alternative to sucrose with less cariogenic potential, which can potentially lower the incidence of Early Childhood Caries (ECC), by means of comparison.

Methods

Primary tooth enamel blocks (n=32) were randomly divided into four groups and exposed to 5% concentrations of the respective test groups (sucrose, xylitol, erythritol and stevia). All samples were inoculated with *S. mutans* standard strain (ATCC 25175) at room temperature. Analysis of Colony Forming Units (CFUs), acidity measurements (pH) and Scanning Electron Microscopy (SEM) observations were done after 6, 12, 18 and 24 h and compared.

Results

After 6 h, the marginal mean CFU count indicated equal *S. mutans* growth in all groups. Stevia showed lower CFU counts compared to other groups at 12, 18 and 24 h. The pH levels for all non-fermentable sugar substitutes (NSS) initially decreased but never below the critical pH=5.5 and stabilized from 12 to 18 h. The pH levels of sucrose dropped and remained below pH=5.5 at all time intervals. The SEM analysis of *S. mutans* supported the CFU results indicating growth in the presence of sucrose and reduction in the presence of the NSS.

Conclusions

Compared to sucrose, xylitol, erythritol and stevia have less cariogenic potential with reduced growth of *S. mutans* and subsequent acidity levels. Stevia had the least cariogenic potential of all the NSS tested, followed by erythritol and then xylitol.

Keywords: Cariogenic potential, erythritol, stevia, *Streptococcus mutans*, xylitol, CFU, pH

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INTRODUCTION

Early Childhood Caries (ECC) is one of the most prevalent diseases in children and a serious concern in public health care systems worldwide.[1] *Streptococcus mutans (S. mutans)*, in the presence of sucrose, is responsible for the onset, presence and development of dental decay in most instances.[2] Studies suggest that the consumption of non-fermentable sugar substitutes (NSS) can affect the metabolism of microorganisms, with subsequent reduction of acidity in the mouth.[3-6] A pH level in the mouth of 5.5 is known as the critical level, as this level of acidity and below leads to disintegration of the organic compound of the enamel and dentine, leading to demineralization and subsequent cavity formation.[7] Limited research regarding the effect of NSS on the metabolism of cariogenic microorganisms and the resulting pH values inspired this study. The effect of sucrose and different NSS (namely xylitol, erythritol and stevia- hereafter refered to as sweeteners) upon the colony forming unit (CFU) of *S. mutans*, pH of the incubation medium and morphological appearance of bacterial cells, were investigated at various intervals over a 24 h period. Findings from this study generated new evidence regarding the use of healthy and safe sugar substitutes to lower the incidence of ECC.

MATERIALS AND METHODS

The research was conducted as a randomized controlled, cross-sectional, observational *in vitro* study of which the methodology is summarized in Figure 1. The aim of the

study was to compare the cariogenic potential of sucrose and sweeteners xylitol, erythritol and stevia.

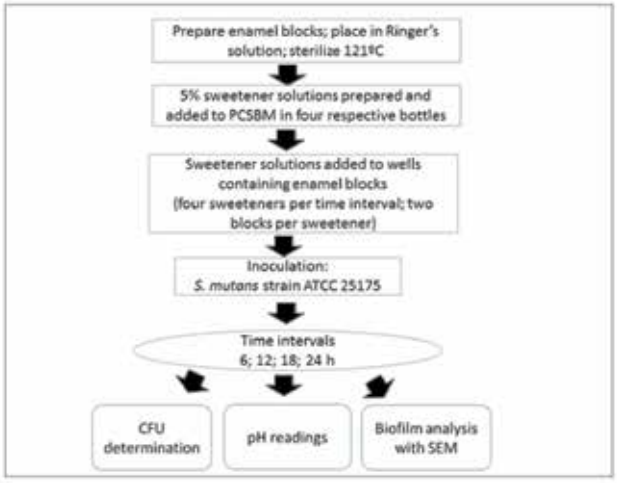

Figure 1: Flow chart to summarize the methodology

Obtaining enamel blocks:

For the results to be applicable to ECC, primary teeth that were extracted as part of a comprehensive treatment plan irrelevant to this study were used. Enamel blocks (2 mm x 2 mm) were produced from the sound buccal surfaces of extracted primary molar teeth, to create a surface for biofilm formation. Blocks were prepared by using a diamond wafering blade in an Isomet 11-1180 low speed saw (Buehler Ltd, Lake Bluff, Illinois, USA). Blocks were sterilised in an autoclave (Already Enterprise Inc., Taipei, Taiwan) at 121˚C for 15 minutes (min). The 32 enamel blocks were grouped in pairs and then divided into four well plates, representative of the four time intervals each containing the respective sweeteners and sucrose as control (2x4x4=32), and placed facing upward in individual tissue wells (Figure 2).

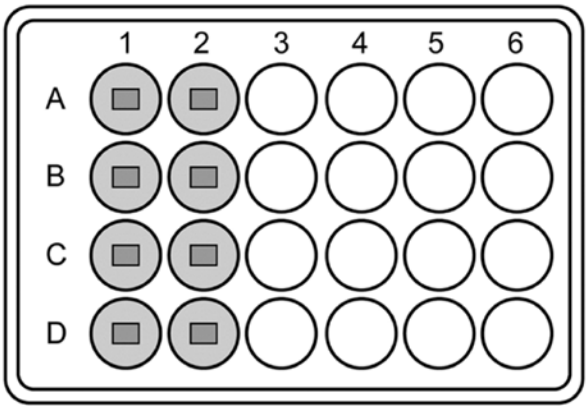

Figure 2: Four well plates, one per time interval, containing enamel slabs and sweetener solution were used

Preparation of sweetener solutions:

The technique described by Pfaffmann et al.[8] was modified and used to prepare the 5% concentration level for the four sweeteners respectively. A preparation was based on weight by volume,[8] and made up by precisely weighing 5 g of a sweetener and dissolving it in 20 mL sterile water. The sweetener preparation was filter sterilized (0.22 µM Millipore filters, Merck SA) and added to Peptone-Casein-Soy-Basal medium (PCSBM) to constitute the final sweetener solutions. The respective sweetener solutions were then added to two wells per well plate respectively (2 wells x 4 sweeteners x 4 well plate = 32). A laboratory assistant prepared the sweetener solutions and added the solutions to the well plates (test groups marked as A, B, C, D) as the lead researcher was blinded to which well plates contained which sweetener.

Inoculation of sweetener solutions:

Solutions in all well plates were inoculated with *S. mutans* standard strain (ATCC 25175), adjusted to a 1% McFarland standard one solution (3 x 10^8 CFU/mL) at room temperature (25±3°C). Microorganisms were tested for purity by means of Gram-staining.[9]

CFU determination:

For the purpose of determining Colony Forming Units (CFU), serial dilution and the spread plate technique (adapted from Bauman et al.[9]) were performed as illustrated in Figure 3. At each time interval (viz. 6, 12, 18 and 24 h) two samples were collected from the well plates harbouring the enamel blocks and sweetener solutions and diluted up to factor 10^{-8}. Each dilution was plated in triplicate to eliminate bias, resulting in 48 plates per group, per time interval (2 samples x 8 dilutions x 3 plates=48 plates available for CFU analysis). All samples, dilutions and well plates were clearly marked.

Petri dishes (90 mm x 15 mm) (Sigma Chemical Co., St. Louis, MO, USA) containing prepared Agar were used for plating. The Agar was prepared by dissolving 5 g Glucose, 23 g Mueler-Hinton Agar and 15 g Bacteriological Agar in 1000 mL distilled, sterilized water. After plating, Petri dishes were placed in a Labotec incubator (Labotec (Pty) Ltd., Midrand, RSA) at 37ºC for 24 h and CFU were assessed and compared to estimate the growth of viable bacterial cells in each sample. The most countable consecutive three dilution ranges were identified within each group, amounting to eighteen plates per group that were assessed for CFU at each time interval. The CFU were counted, by means of the standard plate count method, whereby the CFU were counted and multiplied with the dilution factor. These were then converted to log values.

Determining of pH-values:

At each time interval, the pH value of the media containing the respective sweeteners, was determined in triplicate using a microelectrode pH meter (Oakton pH700 pH/mV/˚C /F Bench Meter).

At each time interval, the two enamel blocks from each group were collected from the well plates for scanning electron microscopy (SEM) analysis to determine the extent of biofilm formation. Samples were placed in marked, sterile well plates and prepared for SEM according to standard methods for biological materials.[10] Enamel slabs were kept in a 96% alcohol solution (Sigma Chemical Co., St. Louis, MO, USA) prior to final preparation. Samples were then placed on spotting plates, covered with 100% alcohol (Sigma Chemical Co., St. Louis, MO, USA) and left for 10 min. The 100% alcohol was gradually substituted with Hexamethyldisilazane (HMDS) (Fluka, Castle Hill, Australia), using disposable Pasteur pipettes and left to evaporate. Hexamethyldisilazane lowers surface tension around the sample and therefore

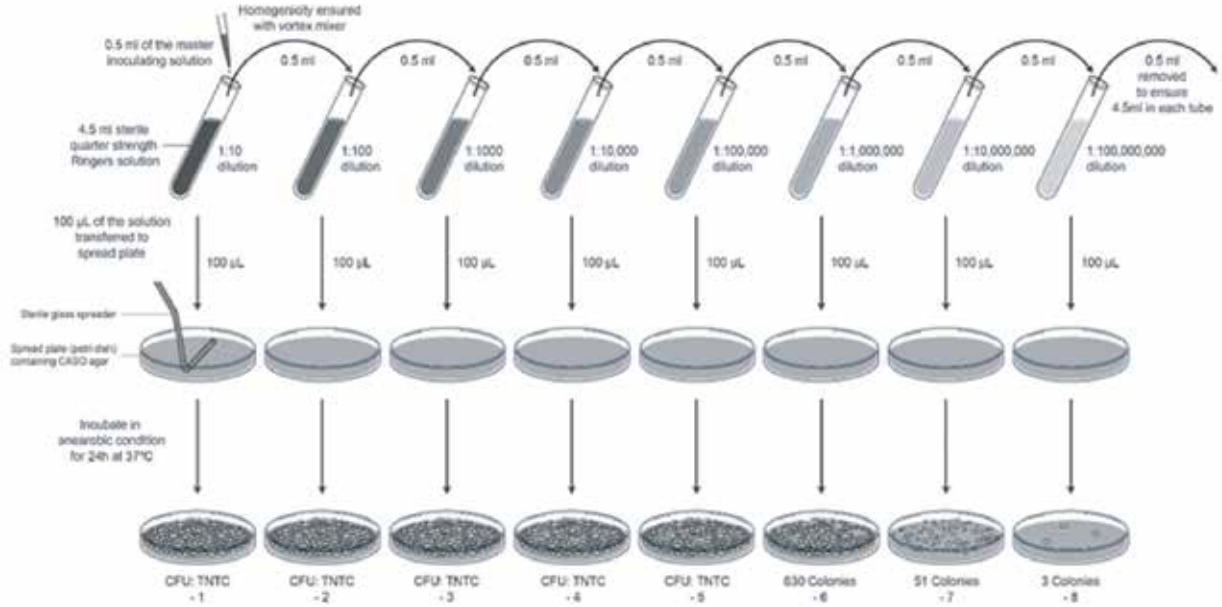

Figure 3: Illustration of the serial dilution and spread plate technique

eliminates the likelihood of distortion of the cells during the final drying stages before SEM examination. The enamel slabs were mounted on stubs, sputter coated with chromium and analysed at 1500x, 3000x and 8000x using a Zeiss Supra 55 VP Field Emission variable pressure Scanning Electron Microscope (FE-SEM) (Zeiss, Germany) at Sefako Makgatho Health Sciences University, South Africa.

Statistical analysis

The data was statistically analysed using a factorial study design with factors sweetener (sucrose, xylitol, erythritol and stevia) and time (6, 12, 18 and 24 h). The data for CFU counts and pH were quantitatively analysed using a two-way analysis of variance (ANOVA), with main factors sweetener and time, inclusive of interaction between factors. The level of significance was set at $p < 0.05$. Descriptive analysis was used for biofilm formation using SEM.

Ethical clearance

Ethical clearance was obtained from the Ethics Committee, Faculty of Health Sciences, University of Pretoria, South Africa (ethical clearance number 86/2019). Ethical and safety guidelines, for the handling and disposal of human teeth and laboratory research were strictly followed.

RESULTS

Comparisons of the CFU between the sucrose and NSS groups at the different time intervals are reported in Table I and illustrated graphically in Figure 4. Significant differences between the CFU count in the presence of sucrose and the respective NSS were noted after the 6 h time interval.

A comparison of the pH values for each group (at different time intervals) are reported in Table II and depicted as a graph in Figure 5. The results in the current study show a direct correlation between the increase in CFU and the decrease in pH value for all groups with the exception of erythritol (Table I, Figure 4, Table II, and Figure 5). When the CFU stabilized or decreased, the pH stabilized or increased accordingly, for sucrose, xylitol and stevia (Table I, Figure 4, Table II, and Figure 5).

Table I Mean differences in log of CFU counts between paired sweeteners at different time intervals

Sweetener pair	Mean difference at 6h	p-value	Mean difference at 12h	p-value	Mean difference at 18h	p-value	Mean difference at 24h	p-value
Xylitol vs Sucrose	-0.03	0.575	0.20*	0.003	-0.13*	0.042	-0.08	0.188
Erythritol vs Sucrose	0.03	0.618	-0.01	0.918	-0.01	0.904	0.49*	0.001
Stevia vs Sucrose	0.07	0.213	-0.42*	0.001	-0.19*	0.003	-0.03	0.636
Erythritol vs Xylitol	0.06	0.296	-0.20*	0.003	0.12	0.053	0.57*	0.001
Stevia vs Xylitol	0.11	0.080	-0.62*	0.001	-0.07	0.245	0.05	0.385
Stevia vs Erythritol	0.04	0.442	-0.41*	0.001	-0.19*	0.005	-0.52*	0.001

*The mean differences in CFU are statistically significantly different, at p<0.05

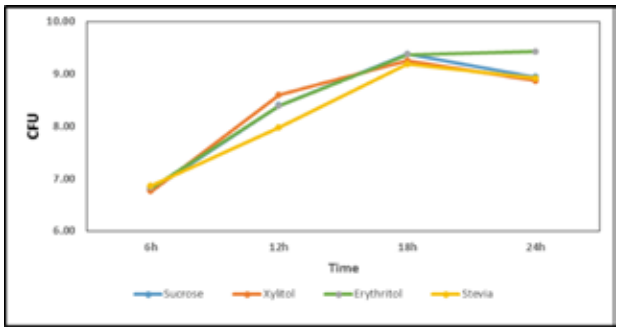

Figure 4: Display of marginal mean for mean CFU counts for various treatments over time

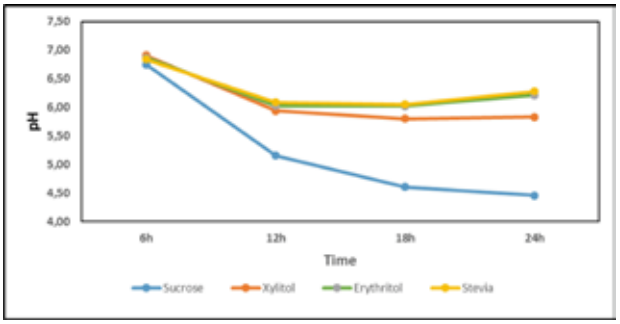

Figure 5: Display of marginal means for pH values over treatment and time

The SEM images of the current study show clusters of *S. mutans* in the presence of sucrose at 12 h and 18 h (Figure 6). However, stressed *S. mutans* cells could be observed in the presence of erythritol at 18 h and 24 h (Figure 6). Scanning Electron Microscopy also revealed stressed bacterial cells with cob-web-like structure in the presence of stevia at 18 h and 24 h (Figure 6). Bacterial cells were only found in sheltered areas in the presence of xylitol at 12 h (Figure 6).

DISCUSSION

Sucrose

It was observed that sucrose showed statistically significant higher CFU counts than the NSS tested, with the exception of erythritol, at all the time intervals and xylitol at 12 h. Sucrose serves as substrate for *S. mutans,* enabling it to multiply and grow.[11-12] Frequent and excessive intake of sucrose, therefore result in elevated levels of *S. mutans* in saliva.[11-12] The SEM analysis also confirmed positive growth of *S. mutans* at all time intervals in the presence of sucrose (Figure 6a, b). Sucrose is known to cause a drop in oral pH because of bacterial fermentation of ingested sucrose, glucose, fructose, refined carbohydrates and cooked starches.[11-13] After 12 h, the pH value for sucrose was statistically lower than the pH values of xylitol, erythritol and stevia for all time intervals (Table II, Figure 5).

Xylitol

The significant difference between the CFU count for xylitol and sucrose at the 6 h interval can be attributed to the fact that xylitol has a similar structure to sucrose and is therefore initially recognized by the microbial cell as a potential nutrient. Xylitol enters the bacterial cell and is expelled from the microbial cell as xylitol again, thus not utilized by the bacteria as a source of energy.[14-15] Miyasawa et al.[16] found that in the presence of xylitol, the lactic acid end-product of the metabolic pathway of bacteria is decreased, but that formic and acetic acids are increased which may support the initial drop in pH reported in this study.[16]

The SEM analysis produced corroborating evidence about the attachment of bacterial cells to the enamel surface. Although the CFU count in the presence of xylitol was higher than that of the other NSS at 12 h, there were not many bacterial cells visible on the enamel surface (Figure 6g). This is in line with the findings of Badet et al.[17] where the clear inhibitory effect of biofilm formation in the presense of xylitol was demonstrated. This is also substantiated by the findings of Jacques et al.[18] in an earlier study, stating that xylitol leads to a reduction in lipoteichoic acid, which is essential for adhesion to the enamel surface. Although the pH value measured for xylitol was statistically lower than those of erythritol and stevia after 24 h, it stabilized and never dropped below the critical level of 5.5 (Table 2, Figure 5).

Erythritol

The CFU for erythritol was statistically higher than the CFU for all the other sweeteners at 24 h (Table1, Figure 4), and is supported by is similar to an *in vivo* study whereby the growth of *S. mutans* in the presence of erythritol was inhibited only during later growth

Table II Pairwise comparison of pH values measured for sweeteners at different time intervals

Sweetener pair	Mean difference at 6h	p-value	Mean difference at 12h	p-value	Mean difference at 18h	p-value	Mean difference at 24h	p-value
Xylitol vs Sucrose	0.17*	0.046	0.78*	0.001	1.19*	0.001	1.37*	0.001
Erythritol vs Sucrose	0.12	0.133	0.87*	0.001	1.41*	0.001	1.745*	0.001
Stevia vs Sucrose	0.09	0.267	0.93*	0.001	1.45*	0.001	1.82*	0.001
Erythritol vs Xylitol	-0.04	0.567	0.09	0.259	0.22*	0.011	0.37*	0.001
Stevia vs Xylitol	-0.08	0.323	0.14	0.081	0.26*	0.004	0.45*	0.001
Stevia vs Erythritol	-0.03	0.670	0.05	0.498	0.37	0.640	0.07	0.354

*The mean differences in CFU are statistically significantly different, at p<0.05

phases.[19] Certain bacterial cells still seemed turgid and healthy while others seemed to have died with cob-web-like attachments anchoring them to the surface of the enamel at 18 and 24 h (Figure 6c, d). The elevation in the pH value for erythritol from 18 h to 24 h may be attributed to an altered metabolic cycle of *S. mutans*, which is in correlation with a longitudinal study conducted by Runnel et al.[20] that reported that bacteria in erythritol produce less acid compared to other polyols over time.

Stevia

The increase in CFU count for stevia after 6 h may be due to *S. mutans* that recognised the NSS as potential source of nutrition and the presence of carbohydrate bulking agents.[21] At 12 h, the CFU for stevia was statistically lower (Table I, Figure 4) compared to all the other sweeteners and also evident in the SEM analysis with very few cells visible on the enamel structure (Figure 6e). Although studies have confirmed stevia's inhibitory

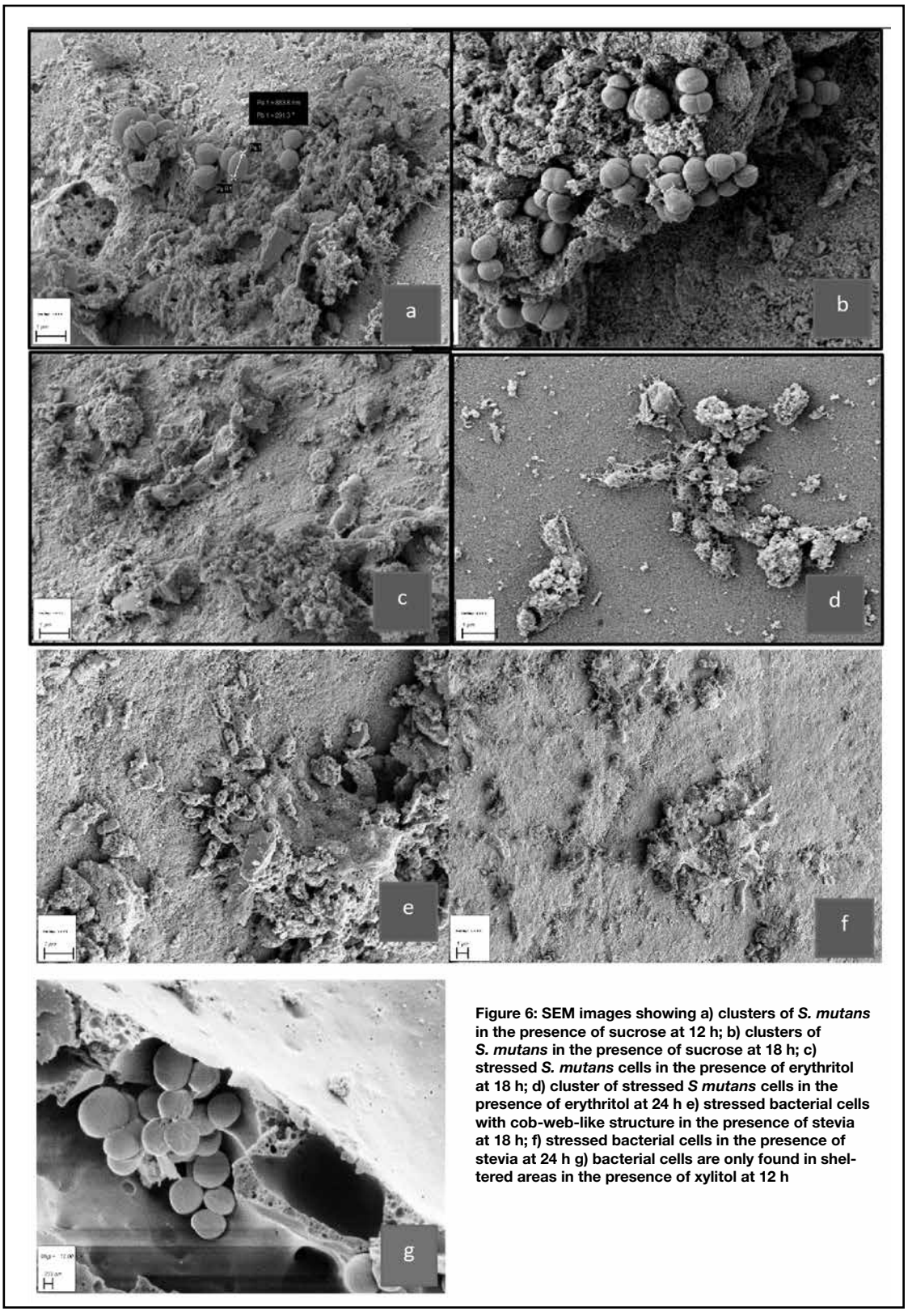

Figure 6: SEM images showing a) clusters of *S. mutans* in the presence of sucrose at 12 h; b) clusters of *S. mutans* in the presence of sucrose at 18 h; c) stressed *S. mutans* cells in the presence of erythritol at 18 h; d) cluster of stressed *S mutans* cells in the presence of erythritol at 24 h e) stressed bacterial cells with cob-web-like structure in the presence of stevia at 18 h; f) stressed bacterial cells in the presence of stevia at 24 h g) bacterial cells are only found in sheltered areas in the presence of xylitol at 12 h

effect on growth of bacteria, research is still lacking on the exact mechanism.[22-23] It is however postulated that stevia inhibits the formation of polysaccharide, necessary for bacterial cell adhesion and dental biofilm formation.[7] The lower CFU count for stevia at 12 h may also be attributed to the exhaustion of carbohydrate bulking agents and the incapacity of *S. mutans* to metabolize stevia with subsequent inhibition of growth of the microorganisms.[14-15] The CFU for stevia dropped significantly after 18 h (Table I, Figure 4), which was again confirmed with SEM where only a few bacterial cells were observed and dead cells, forming cob-web-like structures seen on the enamel surface (Figure 6f). Although there was an initial drop in the pH value in the presence of stevia, the value stabilized after 12 h and was elevated after 18 h (Figure 5). This elevation of pH is similar to the findings of Giacaman et al.[7] whereby stevia had significant lower acidogenicity compared to other commercial sweeteners.

Overall

The significance of the pH level of the media containing sucrose dropping below pH=5.5 and remaining below this critical level, should be highlighted. The CFU and SEM observations indicate positive bacterial growth in the presence of sucrose, with growth retardation of NSS confirmed with SEM. Although the CFU counts do not reflect this throughout the experiment, it can be attributed to the solid tooth structure vs. liquid medium not providing equivalent conditions in providing bacterial attachment. However, *S. mutans* activity and metabolism is a causative factor of dental caries due to acid production.[24] The results of the study therefore confirmed that the NSS, xylitol, erythritol and stevia, have a lower cariogenic potential compared to sucrose, ***in vitro,*** since none of the NSS tested produced a pH lower than 5.5.

Limitations

The limitations of this *in vitro* study are that it did not fully mimic the *in vivo* environment that is influenced by buffering of saliva, variable salivary flow rates, different quantities of bacterial material on teeth and the variety of bacteria capable of producing acid or alkaline substances.

CONCLUSION

This study yielded justifiable evidence that NSS (xylitol, erythritol and stevia) have less cariogenic potential when compared to sucrose. Considering CFU counts, pH values and SEM analysis over 24 h, stevia showed the least cariogenic potential of all the NSS tested, followed by erythritol and then xylitol. The safe and effective way to incorporate NSS, as sugar substitutes in the daily diet of children, which can ultimately contribute to lowering the incidence of ECC, should however be further researched.

Conflict of interest

There was no conflict of interest.

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Pharmaceutical cost implications for oral healthcare interventions at a dental clinic in Windhoek, Namibia

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BS Singu[1], P Shaamena[2]

ABSTRACT

Introduction

Half of the world's 7.9 billion population suffers from oral health conditions. Most are largely preventable and treatable but costs are often unaffordable especially in developing countries. The World Health Organization (WHO) resolved in 2021 to include oral healthcare interventions in universal healthcare coverage (UHC) programmes. Although the general expenditure on oral healthcare services has been reported by some countries, amounts spent on particularly pharmaceuticals have not been reported.

Aims and Objectives

This study aimed to report on the prevalence of different types of oral health diseases in patients attending a dental clinic in Windhoek (Namibia) and quantify the pharmaceutical expenditure incurred.

Methods

Records for all patients who visited the dental clinic at KIRH during a six-month period (1 January 2021 to 30 June 2021) were reviewed. Costs associated with the respective pharmaceutical management options for the most common oral conditions were calculated based on the approximated cost for a single treatment course per patient.

Results

Pharmaceutical expenditure on oral diseases was approximately 0.4% of the hospital's annual budget. From this, 94.6% was due to treatment of dental caries which had a 90.1% prevalence. Prevalence of dental caries among 13-19 years age group (9.5%) was lower than for 1-12 years (18.6%) and 20-64 years (68.2%). Cases for dental caries were fewer for the 65+ years age group (3.8% of total cases) but had the highest prevalence (95.2%) of dental caries then other age groups.

Conclusions

The proportion of the pharmaceutical budget spent on treating oral diseases was 0.4%, of which 94.6% was due to dental caries. Promotion of oral healthcare among children may be instrumental in reducing the pharmaceutical costs associated with treatment of dental carries.

Keywords: oral health, dental caries, universal healthcare, pharmaceuticals, costs, Namibia.

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2. Priscila Shaamena 30%

INTRODUCTION

Approximately half of the world's 7.9 billion population suffers from oral health conditions.[1] Most oral diseases are largely preventable and treatable if presented earlier but treatment is usually not part of universal health coverage (UHC) packages and often unaffordable especially in developing countries; for this reason, the World Health Organization (WHO) resolved in 2021 to include oral healthcare interventions in UHC programmes.[2,3] However, financing of medicines, fees for consultations, and procedures are known barriers to implementation of UHC especially in Low- and Middle-income Countries (LMICs).[4] Although the general expenditure on oral healthcare services has been reported by some countries to be around 5%, the amounts spent on pharmaceuticals in particular as part of treating oral diseases has not been reported.[5,6] The purpose of this study was to report on the prevalence of different types of oral health diseases in patients attending the dental clinic at Katutura Intermediate Referral Hospital (KIRH) in Windhoek (Namibia) and quantify the pharmaceutical expenditure incurred in treatment of patients at this clinic.

Namibia is a LMIC African country with an estimated population of 2.5 million. Its total expenditure on health is roughly 8.9% of its Gross Domestic Product (GDP).[7,8] Windhoek, the capital city of Namibia, has around 400,000 inhabitants of which the vast majority's health needs are served by KIRH, the busiest hospital in the country. The dental clinic located at this hospital is visited by 80 patients per day, and has a staff compliment of 8 dentists, 6 dental assistants, 1 nurse, 1 dental lab technician, and 1 prosthodontic specialist.

METHODS

Data for this retrospective study were retrieved from register books at the Dental Clinic of KIRH, Windhoek, Namibia. Records for all patients who visited the clinic during a six-month period (1 January 2021 to 30 June 2021) were reviewed and included in the data analysis

Table I: Pharmaceutical costs associated with managing various dental conditions (calculated per patient)

Dental condition	Pharmaceutical management	Cost per patient (US$)
Dry socket	Chlorhexidine 0.2% mouth wash +Alvogyl ointment	1.00
***Tooth extraction**	Lignocaine 2% dental cartridge (2 ampoules)	0.84
Abscess	Amoxicillin 500 mg (or Cefuroxime 500 mg) + Metronidazole 400 mg + Paracetamol 500 mg for 5 days	0.48
Pericoronitis	Amoxicillin 500 mg (or Cefuroxime 500 mg) + Metronidazole 400 mg + Paracetamol 500 mg for 5 days	0.48
Cavities	Ibuprofen 400 mg + Paracetamol 500 mg for 5 days	0.22
Impacted tooth	Ibuprofen 400 mg + Paracetamol 500 mg for 5 days	0.22
Dental trauma	Ibuprofen 400 mg (or Paracetamol 500 mg) for 5 days	0.13
Retained teeth	Ibuprofen 400 mg (or Paracetamol 500 mg) for 5 days	0.13
Mobile teeth	Ibuprofen 400 mg (or Paracetamol 500 mg) for 5 days	0.13

*Not a dental condition, included to capture pharmaceutical cost.

Table II: Demographic characteristics of patients who attended KIRH dental clinic in Windhoek, Namibia

Characteristic	Proportions (n = 4108)
Sex, n (%)	
Male	1706 (41.5%)
Female	2402 (58.5%)
Age in years	
1-12	733 (17.8%)
13-19	414 (10.1%)
20-34	689 (16.8%)
26-35	1188 (28.9%)
36-64	938 (22.8%)
≥65	146 (3.6%)
median (range)	27 (1-93)
Dental conditions presented	
Cavities	3702 (90.1%)
Pericoronitis	84 (2.0%)
Dry socket	76 (1.9%)
Impacted teeth	57 (1.4%)
Abscess	50 (1.2%)
Dental trauma	39 (1.0%)
Retained teeth	30 (0.7%)
Mobile teeth	12 (0.3%)
Other	58 (1.4)

Table III: Approximate pharmaceutical costs associated with treating an individual dental condition

Dental condition	Annual Cost (US$)	Proportion of Total Annual Cost (%)
Cavities	10,540.99	94.6
Pericoronitis	196.8	1.8
Abscess	146.84	1.3
Retained teeth	83.57	0.7
Impacted teeth	81.07	0.7
Dental trauma	59.02	0.5
Mobile teeth	22.41	0.2
Dry socket management	12.69	0.1
Total	**11,143.39**	**100.0**

if they had all required information, which were: age, sex, diagnosis/dental condition, and treatment/intervention. The costs associated with the respective pharmaceutical management options for the most common dental conditions were calculated based on the approximated cost for a single treatment course per patient, the exchange rate at the time of this study was 1.00 United States Dollar = 15.00 Namibian Dollars, (Table 1). Descriptive statistical analysis to summarize the results were performed using Microsoft® Excel, version 16.53 (Microsoft Corp., Redmond, Washington, USA).

Approval to conduct this study was obtained from the Ministry of Health and Social Services (MoHSS) Ethics Committee.

RESULTS

Of the total 6,516 patients seen at the Katutura Hospital dental clinic during the six-month study period (1 January - 30 June 2021), 2,408 were excluded from the data analysis due to missing data such as age, sex, diagnosis, or treatment/intervention. The 4,108 patients included in this study had a median age of 27 years (range:1-93 years) and comprised of 1,706 (41.5%) males and 2,402 (58.5%) females. The 26-35 years age group were the largest patient group (28.9%) while the 65+ years group had the lowest numbers (3.6%). More patients came to the clinic for the first time (59.5%) than for a follow-up visit (40.5%). The most common dental conditions presented at the clinic (Table 2) were cavities (90.1%), pericoronitis (2.0%) and dry socket (1.9%). For cavities alone, the age group of 1-19 years accounted for 28.1%, those between 20-25, 26-35 and 36-64 years together (adults) accounted for 68.2%, while the 65+ years group was 3.8% of the cases (Figure 2). Within age groups, the highest prevalence of dental carries was among the 65+ year-olds (95.2%), followed by the 1–12-year-olds (94.9%) and the lowest being within the 13–19-year-olds (87.2%).

Only a small number of patients (0.2%) received no intervention/treatment on the date of their visit, the vast majority received at least one intervention; 12.1% had 1 intervention, 85.8% had a combination of 2 interventions, and 1.9% had 3 interventions. The most common interventions (Figure 1) were tooth extraction (46.4%), medication (28.2%), and dental x-ray (22.0%). Disease conditions due to infections were treated with combination therapy (taken orally) of amoxicillin (or cefuroxime) + metronidazole + paracetamol for 5 days while pain was managed by common analgesics mostly paracetamol and/or ibuprofen for 3-5 days. The calculated pharmaceutical costs for the 4,050 patients (excluding 58 which were counted as 'Other') was US$ 3,482.31 over the study period. Adjusting this figure to include all the 6,516 patients who presented to the dental clinic during the six-month study period and projecting

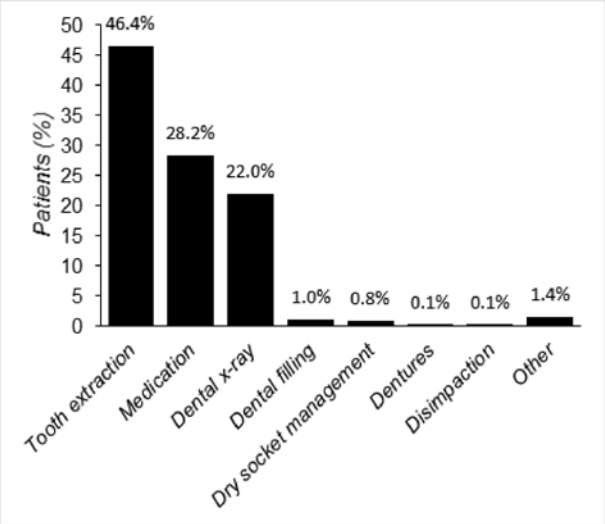

Figure 1: Frequency distribution of interventions at the KIRH dental clinic

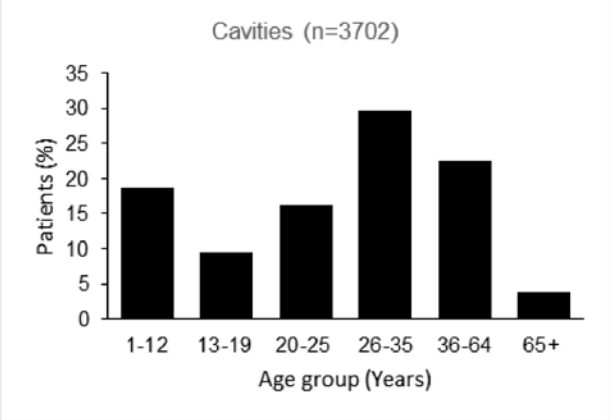

Figure 2: Frequency distribution of patients with cavities attending the dental clinic at KIRH. Patients were classified according to economic age groups (n=3702).

the costs to 12 months (13,032 patients) brings the total annual pharmaceutical costs at this clinic to approximately US$ 11,143.38 which is 0.4% of the total pharmaceutical budget for the entire hospital. Disease conditions that incurred the highest annual pharmaceutical costs were cavities (dental caries), pericoronitis, and abscess (Table 3).

DISCUSSION

The WHO reports that access to prevention, early diagnosis and treatment of oral diseases is far from universal and remains unattainable for millions of people in poor nations.[3] Although it is commendable that WHO intends to implement the primary healthcare strategy of promoting community-based preventative interventions such as water fluoridation and advocating for recognition of fluoride tooth paste as an essential health product,[3] it is necessary for the cost of pharmaceuticals to also be considered in order to address the aspect of access to treatment. While access to essential medicines is regarded as vital to achieving UHC, it is known that the majority of people in low- and middle-income countries (LMICs) have no access to essential medicines mostly due to a lack of financing.[9] Quantification of pharmaceutical costs associated with treatment of dental conditions will help policy makers and governments of LMICs to make informed decisions in efforts to include oral healthcare interventions in their UHC programmes.

In this study, the interventions made on outpatients who attended a dental clinic at a major state hospital in Windhoek (Namibia) were studied and the pharmaceutical costs associated with treating each of the mostly presented oral health diseases were estimated. At KIRH, 74.6% of the patients who visited the dental clinic received an intervention that involved the use of pharmaceuticals (Figure 1). The total annual cost of pharmaceuticals required to treat patients at this dental clinic was estimated at US$11,143.38 which is 0.4% of the hospital's entire budget allocated to pharmaceuticals in 2021. The hospital at which this study was conducted is one of the two largest state hospitals in Namibia and it is unlikely that the proportion of pharmaceutical costs for dental interventions at this hospital would be the same at all the other state hospitals around the country, therefore generalizing this figure to be true at the national level is a limitation. Nonetheless, using this figure of 0.4% and taking the reported national annual expenditure on pharmaceuticals for Namibia as US$58,300,000.00,[6] the corresponding national cost on pharmaceuticals for treating oral health diseases would be inferred to be around US$233,200.00, of which roughly US$220,600.00 goes to treating cavities alone. Since cavities were the most commonly presented condition, as is reported globally,[10–12] it is not surprising that such a high proportion (94.6%) of the estimated pharmaceutical costs at this dental clinic were due to treatment of this disease. The majority of patients with dental caries in this study were adults (68.2%), followed by children (18.6%), adolescents (9.5%) (and a small percentage were elderly (Figure 2). These demographics suggest that oral hygiene seems to be better in the high school age group (13-19 years old) in comparison to pre-primary and primary school children (1-12 years old).

However, the elderly are the worst affected by dental caries as an age group. It could be argued that promotion of oral health hygiene in primary school children could lead to a reduction in the high prevalence of dental caries in the older age groups and therefore result in lower pharmaceutical expenditure on treatment. Studies have demonstrated the cost-effectiveness of preventative interventions against dental caries in children such as promotion of the use of fluoridated tooth paste and water fluoridation.[13] However, there is a gap in the literature with regard to pharmaceutical costs associated with the treatment of dental carries and other oral health diseases in both high-income countries and LMICs. Namibia's reported expenditure on general dental treatment is around 5% of total health expenditure, which is the same figure reported for high-income countries.[5,6] LMICs fail to provide services for prevention and treatment of oral health conditions majorly due to a lack of UHC programmes.[14] In essence, the objectives of developing UHC packages are to provide good value for money spent on healthcare, and address a significant disease burden, such as dental carries.[15] Countries are encouraged to have financing systems that enable provision of all types of UHC services such as promotion, prevention, treatment and rehabilitation at the lowest cost possible.[4] As policy makers in LMICs begin to implement the resolution by WHO to include

oral healthcare interventions in UHC programmes, the associated pharmaceutical expenditure must be taken into account to enable sincere financial assessments and adoption of better-informed financing strategies.

In conclusion, dental caries was the most commonly presented oral disease at this dental clinic accounting for 90.1% of all disease conditions and 94.6% of pharmaceutical expenditure on treating oral diseases. This study has suggested an estimate of around 0.4% of the local or national pharmaceutical budget for provision of pharmaceutical management of oral health conditions. Promotion of oral healthcare practices among primary school children may be instrumental in reducing the pharmaceutical costs associated with treatment of dental carries. In designing and implementing UHC programmes, LMICs should not only consider preventative strategies, but also the pharmaceutical costs associated with treating oral diseases.

Conflicts Of Interest

The authors have no conflicts of interest to declare that are relevant of the content of this article.

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Facilitating technology-enhanced external examination moderation during the Covid-19 pandemic

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N Potgieter[1], N Mohamed[2], RJ Vergotine[3], CW Peck[4]

SUMMARY

Introduction

Due to the Covid-19 pandemic and associated travel restrictions, the physical presence of international external examiners was a challenge when assessing the exit level outcomes of the MSc (Dent) in Paediatric Dentistry at the University of the Western Cape.

External moderation of final examinations ensure an acceptable standard, coverage of content as specified by the programme outcomes and eliminates bias during assessment. Internationalization of the moderation and examination process allows countries to compare and maintain international standards and graduate attributes expected for professional qualifications.Qualifications requiring assessment of skills often rely on Objective Structured Clinical Examinations, Objective Structured Practical Examinations and simulated cases in combination with an oral examination, which requires the presence of all examiners to assess the student.

Aims and objectives

This paper describes how the final examination in this MSc (Dent) degree was adapted and conducted in order to overcome the challenges of the Covid-19 pandemic, to maintain the academic integrity and rigour of the programme.

Design and Methods

A narrative essay-style approach was adopted, which reflects on the challenges and opportunities created by Covid-19.

Conclusion

The adapted assessment method proved to be an effective alternative to the more traditional assessment approaches employed pre-Covid.

Key words: International External Examiner, Virtual Oral Examination, Adapted Assessment, Covid-19 pandemic, Assessment Challenges.

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INTRODUCTION

The MSc (Dent) Degree in Paediatric Dentistry is a full-time two year clinical programme that not only requires in-depth theoretical knowledge but also proficient clinical skills and professional competency during patient interactions. It is essential that the application of theoretical knowledge is assessed together with clinical skills throughout the course in the form of continuous assessment, but specifically at the end of the course by means of a final exit level examination. This MSc (Dent) differs from most other MSc programmes as well as the MSc (Dent) in Paediatric Dentistry by-thesis, in that it has an integrated clinical component as part of the degree over the two years.

The assessment practices implemented were guided by the assessment policy for post-graduate students of the University of the Western Cape (UWC), South Africa.[1] Continuous assessment was weighted at 60% and the final summative assessment at 40% of the final mark. This has potential of enhancing fairness of the departmental assessment practices, in that it places more emphasis on student achievement and progression over the two-year degree than on a final high-stakes examination.

The final examination was structured to include a written theoretical examination (40%), a case-based written

examination (20%), an online e-portfolio (20%) and a comprehensive oral examination including a simulated case (10%) and a presentation of a prepared case (10%). An independent external examiner plays a crucial role in ensuring an objective analysis of examinations and student performance. The Department of Paediatric Dentistry at UWC utilised the services of an external examiner from the University of Michigan in the United States of America. since 2016. The external examiner moderated and participated in all the components of the final examination as explained below.

Written theoretical and Case-based examinations

Sound theoretical knowledge is essential for application in the clinical context. The written theoretical examination consisted of essay questions, which were marked independently by more than one assessor to improve reliability, and short questions that had a clinical slant but with the focus on in-depth theoretical knowledge. Questions covered the entire spectrum of content addressed in seminar discussions and article critiques during the two years and are aligned with the learning outcomes as stipulated in the study guide. Content validity is thus ensured.[2] Consequential validity is not an issue as blueprinting of the content ensures that topics are evenly distributed.[3] All content is weighted equally[2] as students are required to have a broad idea of all aspects of Paediatric Dentistry.

A case-based written examination, continuous clinical assessments and an e-portfolio (which will be discussed later) cover the clinical competency assessment in this module. The questions in the case-based examination were similar to case summaries,[4] where students are presented with a clinical scenario including a history with accompanying photographs and radiographs. A series of clinical questions was based on the case. Students were then required to make deductions regarding the management and treatment options based on the information provided. The main focus of this exam paper was to assess the student's ability to critically apply their knowledge to the clinical context, by requiring them to interpret and diagnose the clinical problem and draw up a treatment plan. Both the written examinations were compiled by a minimum of three departmental staff members and were then moderated by the external examiner. The external examiner was totally independent in that he was not involved with the training of the students who were being assessed. Making use of more than one examiner improves reliability and fairness.[2, 5, 6]

All examination papers and memoranda were moderated in advance of the examinations purely via email using password protected documents to maintain confidentiality. Open discussion and exchange of opinions allowed for moderation and adaptation of the papers and memoranda before the examination. Question papers were also moderated to ensure clarity of wording, degree of difficulty and content validity.[5] This moderation process was a positive experience which reinforces the standard of training by ensuring that people are being assessed in a consistent, accurate, and well-designed manner and that assessors use comparable assessment tools and methods. This translates to making analogous and consistent judgements about learners' performance and the scope of work covered. Both the internal and external examiners were satisfied with the papers.

The quality of handwritten answer sheets is always a challenge due to legibility of writing. For the first time in 2021, answers were typed in a word document instead of being handwritten. Each answer sheet was set up in a word document and was labelled with the student number as a footer on each page. Question numbers and section breaks separated the different sections. This method was preferred by both students and examiners and allowed for greater clarity, ability to organize thoughts more coherently and removed the issue of illegible handwriting. Sharing of the document was also easier.

Students were allowed adequate time to complete the written examinations, which took variations in typing speeds into account, for example. This therefore ensures validity[3] and fairness, by ensuring the assessment is student-focussed. According to the university's assessment policy, a minute should be allocated per mark, but additional time was factored in to accommodate for the fact that most international students in this programme only had English as a second or third language. As most of the cases required interpretation, planning and formulation of treatment plans, additional time was allocated. Students were also encouraged to ask questions during the examination if clarity was required on any aspect.

After completion of the examination, the document was saved as both a word and pdf version in the presence of the student to ensure that no changes could be made after the examination. The different sections were emailed to the various internal examiners and combined again after marking. The use of a memorandum and the fact more than one assessor graded the papers, improves the reliability of the assessment. Of the examination components, the written examinations carry the highest weighting. This is justified as more value may be placed on a reliable written assessment compared to an oral examination.[7] The completed, marked scripts were then sent to the external examiner for moderation. The moderation of the written papers prior to the examination as well as after marking, was not experienced as a challenge as it could all be done online.

e-Portfolio

Students shared their e-portfolios with all the internal and external examiners three weeks before the oral examination. The portfolios included their seminar presentations, written assignments, and case presentations that were completed during the course of the programme. Portfolios have been shown to be a good way for monitoring student progress and assessing competence development.[8] The e-portfolios were easily accessed internationally, making it possible for the quality of the programme to be assessed in greater depth.

The e-portfolios gave insight into the depth of understanding and application the students have regarding theoretical knowledge, but also showcased their clinical competency. In this programme, it is used to demonstrate a variety of cases and students have to

reflect on the treatment options with motivation from the literature. It is therefore an indicator of the student's progress and growth in the discipline.[7, 9]

The patient cases that are included in the portfolio have either been presented in the clinic or during the case presentations. Students have therefore received feedback on these cases prior to inclusion in the e-portfolio. These cases have also been assessed by different supervisors in the clinics. Portfolios are assessed by at least three examiners (two internal and one external) which addresses some of the subjectivity associated with portfolio assessment[10] and improves reliability. The use of a rubric and multiple examiners, limits subjectivity and ensures reliability and validity of this assessment method.[11]

Scientific reasoning and referencing were applied in all assignments and case discussions. It was interesting that the e-portfolio marks awarded by the examiners correlated with the Continuous Clinical Assessment marks, which validates the use of an e-portfolio as a final assessment tool. This was not tested statistically, but merely an anecdotal observation.

Oral examination

The oral examination included an unseen simulated case and a presentation of a completed comprehensive case followed by questions and discussion. In preparation for the oral examination, a Google drive folder was shared with all the examiners participating in the examination. The folder contained all continuous assessments up to date, the examination papers, the oral examination simulated case interview script (with memorandum, supplemental images and radiographs), and the rubrics for the oral examination. All examiners had time to familiarize themselves with the contents before the oral examination.

Information Technology played a key role in enabling the oral examination. All the internal examiners and the students were present in one venue with the external examiner joining remotely from abroad. The decision to host the examination both online and on site contributed to creating an examination environment which was conducive to observing the students as well as facilitating discussion. Having more people in a room with a limited number of electronic devices could reduce the chances of unforeseen complications with connections, such as interference and echo on the international call. Background noise and acoustic and audio feedback were experienced when multiple devices were tested in one room at the same time. Only two laptops were set up for communication with the external examiner. The main laptop was used by the module coordinator to share the screen of the simulated case / rubrics or whatever was necessary to share with the examiners. This main laptop was also connected to the projector in the venue, thereby allowing all the examiners to see the images / presentations.

Oral examination – simulated case

The oral examination was structured to start with the unseen simulated case. The clinical examination is intended to assess the students' ability to formulate a diagnosis and motivate their treatment options taking all factors into consideration. A simulated case was considered instead of a patient case which was previously used, as the latter was not standardised and students were exposed to different patients with varied needs. This is therefore not ideal and negatively affects the fairness and validity of the assessment. A child cannot be expected to serve as an exam patient for more than one student where the same procedures are repeated and the same questions are asked. Hence, different patients had to be booked for the students. Additionally, the ethical aspects of using a child as an examination subject remain a challenge.

The student was invited into the examination room and positioned so that the one laptop's camera was facing the student and the actor, who posed as the mother. The student conducted a history by interviewing "the mother". The student followed a systematic approach, obtaining all the necessary information from "the mother". "The mother" followed a script, ensuring that the same information was given to both candidates. This interview process allowed the examiner to evaluate the student's interaction with "the mother", history taking skills, and the ability to identify areas that required further interrogation. The internal examiners observed the interview process directly while the external examiner observed the interview through the aligned laptop.

After the interview, the student was allowed 30 minutes to compile a diagnosis and treatment plan based on the history, additional images and radiographs that were made available to them. This took place in an adjacent office under supervision. Thereafter, students returned to the examination room and presented their diagnosis and treatment plan to the entire panel using the same set-up as before. The external examiner primarily interacted with the students, asking questions and discussing the case. All the internal examiners could however also join in on the discussions throughout. All the examiners used a rubric for assessment of this case.

Oral examination – prepared patient case presentation

For this component of the oral examination, the student presented a comprehensive patient case which showcased the quality of the work they have done. These cases are chosen by the student from the cases already presented during the course of the programme. Due to the stressful and intimidating nature of an oral examination, its reliability and fairness has been questioned,[12] especially when used to make a decision about whether a student should pass or fail.[7] This examination was thus just a formality to confirm their continuous assessment performance. The familiarity of the patient case mitigates the stressful situation to some extent and contributes to fairness of the assessment.

The case was presented as a PowerPoint presentation and included the history, clinical photographs, radiographs, diagnosis and treatment plan as well as a summary of all the treatment completed. Students included their rationale for the treatment and motivation for the choice of materials. After the presentation, the student answered questions posed by the external examiner for this specific case. The external examiner

Table 1: Summary of challenges during the virtual examination

EXAMINATION COMPONENT	CHALLENGES	HOW CHALLENGES WERE OVERCOME	REMAINING CHALLENGES
Written examinations	Moderation	Circulated via email	
	International students – English 2nd language	Extra time allocated for papers	
	Quality of scanned handwritten answer sheets	Typed answers in word document	
Clinical competence	General assessment of competence and scope of procedures done	An e-portfolio with all comprehensive and specific cases completed throughout the programme.	
	Rationale and motivation for treatments carried out as well as student reflection on these aspects	Prepared patient-case presentation	
	Diagnostic skills, interpretation of history and clinical/ radiographic findings	Use of simulated-case(s)	
IT aspects	Sound quality and audio-visual interferences	Only used 2 computers with cameras and 1 computer with audio	Sometimes students spoke too softly. Microphones may be beneficial
	Creating an oral examination environment and viewing the simulated case interview	Combination of online and in person examiners panel	Sometimes the student/ mother moved out of the frame
	Load shedding: interruption of internet connection	Back-up internet sources: hotspot used on mobile phone and/ or alternative venues	
Allocated time	Time difference between USA and RSA	Scheduled programme to start 11am RSA-time and 5am USA-time to allow enough time; adhered to tight schedule	Limited time available. A second meeting to ratify examination results was needed.

led the discussion and asked specific questions regarding motivation for particular procedures and the case in general. Integration and application of content to the clinical context could thus be assessed. A different rubric was used for this presentation.

A discussion between the internal examiner panel and external examiner concluded the exam. All examiners agreed on the standard of the students although the marks were not discussed. Individual examiner marks were tallied after the oral examination. All marks were within a 5% range indicating an agreement between all examiners regarding the standard of the students. In cases where marks were not within a 10% range, an online discussion would have been initiated between the examiners to allow for motivation and consensus.

Table 1 below summarizes the challenges, how they were overcome and ongoing challenges of an oral examination for a clinical module, requiring the services of an international external examiner.

The students' feedback regarding this final examination was obtained through an anonymous online questionnaire. Their expectations of the final examination were met and was expressed as follows by one of the students: "The exam had a lot of variety and we were given a chance to present a case of ours. I liked the variety of assessment tools. And especially the ability to add short cases to the e-portfolio added a lot in terms of giving justice to our clinical work during the program." Students experienced the combination of live and virtual interaction during the oral examination to be effective, however, they would have liked to have more interaction with the external examiner. One of the comments was "not knowing his response or expression through the online connection", which indicates the value of live interaction. The authors acknowledge that although the student cohort was small (two), their comments are of value and useful but using these comments to guide change may be problematic.

All students indicated that, of all the assessment components, they enjoyed the Clinical Written examination the most and that the e-portfolio was an effective tool to showcase their competencies and skills. When students were asked how the examination can be improved, the comments included to have longer time for completing the written examinations and to have mock exams throughout the year to better prepare them for the final examination.

CONCLUSION

1. The COVID-19 pandemic presented significant problems with utilizing an international external examiner for the final examination assessment of the Paediatric Dentistry Masters students at UWC.
2. The use of a remote internet platform alleviated most of the issues that travel restrictions travel placed on the utilization of an international external examiner.
3. Technological issues should be expected when using remote platforms and the development of work-around solutions ahead of time can result in a speedy resolution of issues and alleviate stresses associated with this process.
4. Students are receptive to using remote options for examinations, but would prefer the presence of examiners to improve interactions through face-to-face contact.

5. The combination of an e-portfolio and virtual oral examination are acceptable examination tools for clinical competence while also allowing assessment by an international external examiner.
6. Virtual simulated cases can be an acceptable substitute for live patients. This would address issues created by lockdowns as well as the ethical issues created by using actual patients for examination purposes. Standardisation of the patient case also enhances fairness of the assessment as all students are exposed to the same case.

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Assessing the antibacterial properties of eggshell-titanium powder

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ABSTRACT

Introduction

The global distribution of oral diseases caused by bacterial and the severity of their consequences constitute a pandemic condition.

Aims and Objectives

The present paper reports on the antibacterial properties of a modified eggshell and titanium dioxide using the mechanochemical method.

Methods

EB@TiO_2 was modified and characterized using X-ray diffraction (XRD) while the degradation condition was studied using Thermogravimetric analysis (TGA). The inhibitory properties of EB@TiO_2 at different concentrations (2:1; 3:1 and 4: 1) against both Gram-positive *(E. coli)* and negative bacterial *(B. Cereus)* strain were studied the using disk diffusion method.

Results and conclusions

The XRD result confirmed the presence of a thermodynamically stable calcite structure, which is indicative of calcium carbonate. The diffraction peak of the XRD at $2\theta = 29.5^{o}$ suggests the deposition of TiO_2 on the surface of $CaCo_3$. TGA curves shows the decomposition of anatase form of titanium dioxide and calcium carbonate. The study evidently shows the antibacterial activities of EB@TiO_2 against *Escherichia coli* and *B. Cereus.* The salient feature of the study finding is that modifying eggshells with titanium dioxide improves the antibacterial properties, and thus offers a promising role for the development of potent dental materials in the management of oral diseases.

Keywords: Antibacterial; eggshell; Mechanochemical; titanium dioxide

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INTRODUCTION

Although the oral status of the general population globally has improved, oral disease such as dental caries and periodontitis remains a significant public concern posing a grave challenge for the oral health care provider in mitigation and prevention[1]. From an epidemiological perspective, the World Health Organisation (WHO) underlines that oral diseases like dental caries affect around 60 to 90% of the general population[2,3]. The aforementioned oral disease is mostly caused by bacterial activities in the mouth. Bacteria such as *Streptococcus mutans, Streptococcus sobrinus*, and lactobacilli are the main oral cariogenic pathogens due to their ability to produce high levels of lactic acid following sugar fer¬mentation and their resistance to the adverse effects of low pH[4]. Modern molecular analyses and microbial culture techniques have also demonstrated that an entire range of bacteria can contribute to the caries process at different stages [5]. Besides the aforementioned bacteria species, some classes of fungi like the candida albicans significantly enhance the cariogenic virulence of plaque biofilms[6].

To address and help prevent oral diseases, published literature suggests that brushing regularly with well-formulated fluoride toothpaste can prevent the onset of this disease[7]. Concerning, however, young children may accidentally swallow enough amount of fluoridated dentifrice to produce levels of fluoride consumption associated with a risk of developing dental fluorosis[8]. More so, fluoride is an incessant non-biodegradable, hazardous, and persistent pollutant, which is of concern to the environment. Lacson et al.[9] note that the uncontrolled concentration of fluoride can subsequently cause fluorosis, which is a common fluoride- and water-borne disease. To counteract this looming concern, providing safe, effective, environmentally friendly and affordable material in toothpaste formulation becomes highly important.

Ultimately, eggshells could be an effective environmental alternative in toothpaste formulation. Xia and his team, for example, recently developed a simple defluoridation by boiling eggshell with the addition of acetic acid and sodium phosphate intended for household application [10]. This suggests that eggshells could be a viable alternative to fluoride as it is safe for household use. Moreover, eggshells are utilised in various industries such as dentistry, the pharmaceutical industry and medicine [11]. In dentistry, various studies have illustrated the effective use of eggshells such as Onwubu et al.[12] found that eggshell powder has been successful in reducing the surface roughness of acrylic dentures and Mony et al.[13] concluded that eggshells are capable of re-mineralizing enamel carious lesions. Furthermore, recent studies by Onwubu et al.[14] demonstrate that eggshells modified with titanium dioxide provide robust resistance to enamel demineralization against erosive acids.

Besides this, other studies have reported that titanium dioxide (TiO_2) is an effective antimicrobial agent, and it is compatible with the human body or environment [15, 16]. Given the usefulness of eggshells as a biomaterial, this study envisages that assessing the antibacterial properties of eggshell-modified titanium dioxide ($EB@TiO_2$) will help in validating the material as an alternative dental material in the prevention of oral diseases. To our knowledge, there is limited research that has investigated the antibacterial properties of a modified eggshell and titanium dioxide. The purpose of this study was to assess in vitro the antibacterial properties of a modified eggshell and titanium dioxide against *Escherichia coli* and *B. Cereus* in comparison with commercially available toothpaste.

MATERIALS AND METHODS

Preparation of Eggshell-Titanium dioxide composite (EB -TiO_2)

Modification of eggshell with titanium dioxide was achieved in two steps in accordance with the techniques reported by Onwubu et al. [17]. In the first step, eggshells were ball-milled by placing 30g of the eggshell in a 500ml stainless jar (inner diameter of 100 mm), together with 10 stainless steel balls of 10 mm diameter and dry-milled in a planetary ball mill (Retsch ® PM 100) at 400 rpm for 20 min. The collected powder was sieved to a particle size of ≤ 25µm using a mechanical sieving shaker (Retsch AS 200, Germany). The eggshell powder and titanium dioxide mixing ratio were optimized following the procedure reported by 18, 20g of the fine eggshell powder obtained in step 1 were modified by adding 5g of anatase titanium dioxide (≤ 15µm). The mixture was subsequently ball-milled for 150 min to obtain eggshell-titanium dioxide composite. The prepared powder was subsequently charisterised to determine the phyisco-chemical properties.

Characterization of $EB@TiO_2$

- Fourier Transform Infrared Spectroscopy Analysis
- The infrared spectra were measured using a Perkin Elmer Universal ATR spectrometer to identify the functional group constituents of $EB@TiO_2$.
- Transmission Electron Microscopic Analysis
- A Transmission Electron Microscope (TEM) was used to observe the particle size, shape and distribution of $EB@TiO_2$. Very small quantities of $EB@TiO_2$ were dispersed in 10ml ethanol and sonicated at 10kv for 10 min. Subsequently, thin cross-sections of cryo-microtomed specimens were prepared using a Leica microtome (South Africa) and placed on carbon copper grids. Analysis was conducted using a transmission electron microscope (TEM-Philips CM 120 model) at 120 kV.
- Thermogravimetric analysis
- Thermal degradation and stability of the modified EB-TiO2 were studied using thermo-gravimetric analysis (TGA). The thermal stability was measured using a TA instrument (Thermal Universal Analyser V4.5A). The test was performed under a dry nitrogen gas flow at the rate of 100mL/min from 20°C, at a heating run of 10°C/min.

Antibacterial Assessment of $EB@TiO_2$

The inhibitory properties of $EB@TiO_2$ against both Gram-positive and negative bacterial strains were studied the using disk diffusion method. The Bacterial strain was obtained from Anatech supplies, South Africa. Thereafter, pure colonies from freshly grown strain *E.coli* (ATC 25922), and *B. Cereus* (ATC 10876) were isolated and subsequently trans¬ferred from the plates into a sterile normal saline solution and vortexed to form bacterial homogenous suspensions. The turbidity was then adjusted to 0.5 McFarland standard units, and the suspensions were poured over Mueller–Hinton agar (MHA) plates.

Sterile filter paper disks with a diameter of 6 mm were placed over these plates. The sterile disks were impregnated with 20 µL of the tested compounds (10 mg/mL dissolved in DMSO). Positive control (Ciprofloxacin) and negative control (sterile distilled water) were used. The impregnated plates were incubated at 37°C for 24 hours. in line with the procedure described by Wiegand et al. [19], the inhibition zones were calculated and the value estimated in millimetres.

RESULTS

Characterization

The FT-IR spectra of eggshell powder, titanium dioxide, and $EB@TiO_2$ is presented in Figure 1. The band aspect of the FT-IR spectra shows the difference between the eggshell powder (Figure 1 (A)), $EB@TiO_2$ (Figure 1(B)), and titanium dioxide (Figure 1(C)). The prominent absorption peak of carbonate at 1411 cm-1 was observed for both eggshell powder (Figure 1A) and $EB@TiO_2$ (Figure 1B) suggesting that both materials contain a thermodynamically stable form of calcium carbonate. In addition, the broad stretching displayed for $EB@TiO_2$ above 1000 cm-1 suggests the surface medication of calcium carbonate structure in eggshell powder with titanium dioxide (Figure 1B).

From Figure 2 the TGA curves show the incidence of two thermal events within the temperature range of 50-900°C. The first phase (600°C) is attributed to

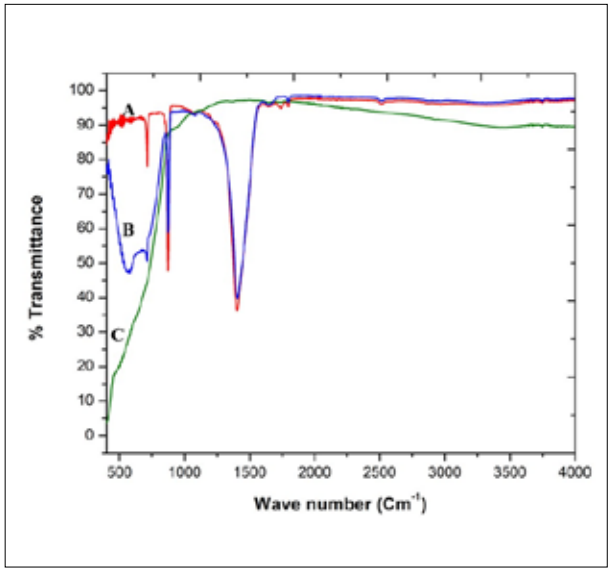

Figure 1: FTIR spectra showing (A) eggshell powder; (B) EB@TiO_2; (C) titanium dioxide

the decomposition of the anatase form of titanium dioxide, which caused a small weight loss (~ 1.061%). The second phase (699.14°C) is endothermic and is linked to the decomposition of calcium carbonate into carbon dioxide and calcium oxide 20.

This weight loss equated to approximately 30.41% of the total mass.

The TEM image of EB@TiO_2 is shown in Figure 3. The image revealed a nonhomogeneous structure of spherical shape particles and irregular particles with different sizes distribution. The irregular shape particles are indicative of eggshell powder while the spherical particles typified the titanium dioxide particles. It can be observed that the pure titanium dioxide particles were scattered on the surface of the composite.

Antibacterial properties

The antibacterial screening of the EB@TiO_2

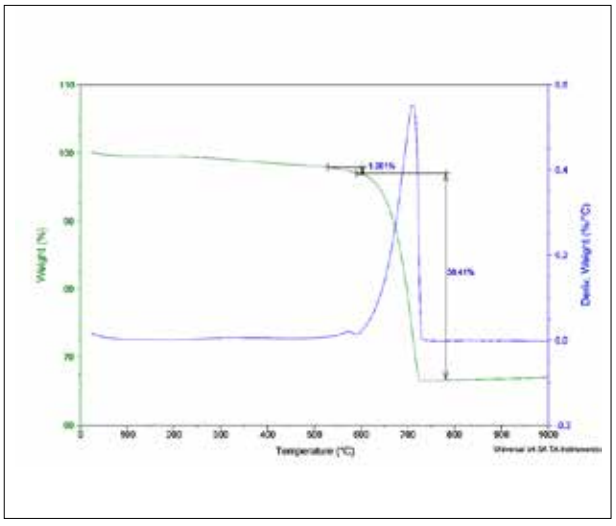

Figure 2: TGA curves of EB@TiO_2

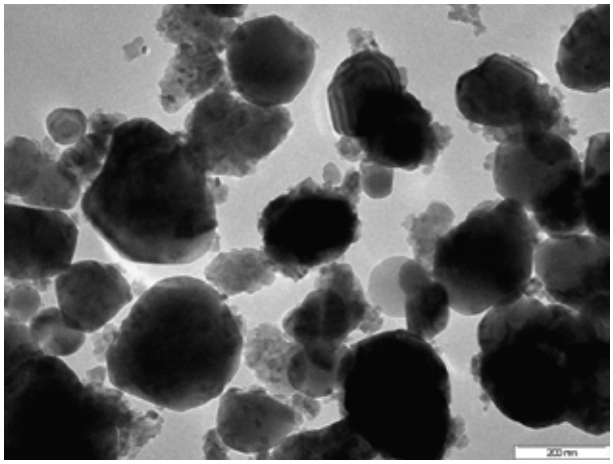

Figure 3: TEM image EB@TIO_2

compounds at different ratios of eggshell and titanium dioxide modification (2:1, 3: 1, and 4:1) was determined using the disc diffusion method against *E. coli* and *B. Cereus*. The results obtained have shown that these compounds displayed a slight inhibition against *E. coli* and *B. Cereus* (Table I). It was also found that irrespective of the ratio of eggshell and titanium dioxide used, the inhibitory properties observed for EB@TiO_2 were more or less the same. On the contrary, tested toothpaste (Colgate Pro-relief, Sensodyne Repair, Sensodyne rapid relief), and eggshell alone didn`t display any inhibition against the bacteria used.

The inhibitory zone observed for EB@TiO_2 at different ratio compositions is given in Figure 4. The image visibly confirmed the inhibitory properties of EB@ TiO_2 against *E. coli* and *B. Cereus*. The inhibitory properties of Ciprofloxacin (Control) demonstrated the maximum zones of inhibition with a mean diameter of 18.6 and 22.5 mm for *Escherichia coli* and *B. Cereus*, respectively when compared to EB@TiO_2 which showed maximum zones of 6 mm.

DISCUSSION

Oral disease such as dental caries continues to pose a significant public health concern due to the associated negative impacts on the quality of life for individual sufferers. Flouride containing toothpaste has largely been the most common effective oral hygiene practice that aids in the prevention of oral disease [7], particularly those caused by bacterial. However, the risks of dental fluorosis, as well as the environmental concern posed by fluoride has necessitated an alternative ingredient in toothpaste formulation. The purpose of this study was to assess in vitro the antibacterial properties of a modified eggshell and titanium dioxide (EB@TiO_2) against *Escherichia coli* and *B. Cereus*. As reported in the literature, some common oral bacteria responsible for dental caries formation include *Staphylococcus aureus* [21], *Escherichia coli*[22], *Streptococcus mutans* [23], *Streptococcus sobrinus* [24], *Lactobacilli sp.* [25], and *Porphyromonas gingivalis* [22]. The finding of this study showed the EB@TiO_2 at different concentrations tested in the study exhibited antimicrobial activity against both *Escherichia coli* and *B. Cereus* (Table 1).

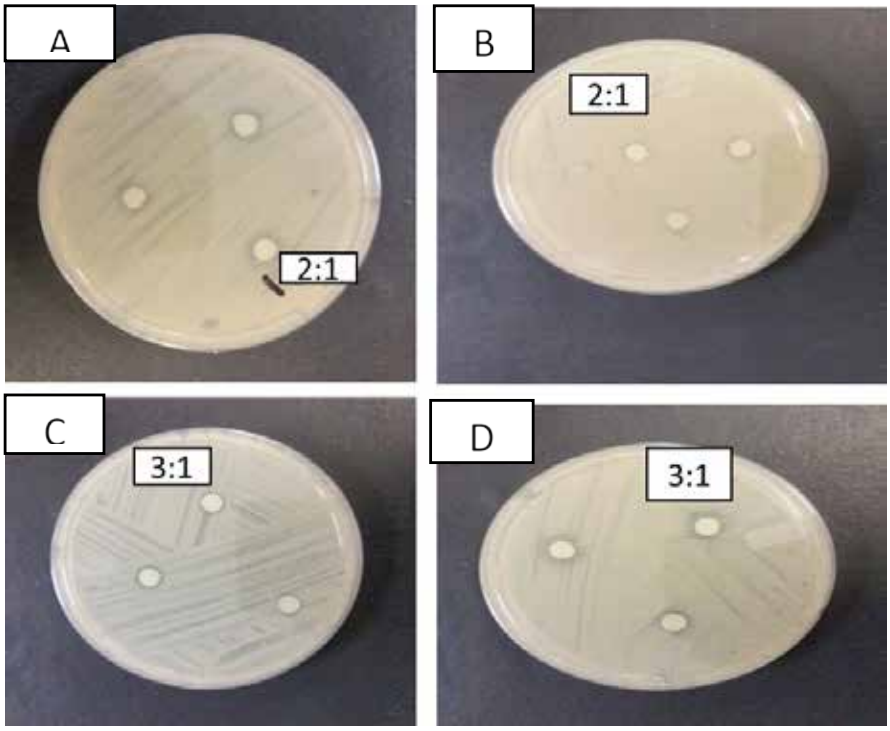

Figure 4: Inhibitory zone (mm) of compounds 2:1 against *E. coli* (A) and compounds 3:1 against *B. Cereus* (B), Compounds 3:1 against *E. coli* (C), compound 3:1 against B (D) against *B. cereus*

Comparison of the zones of inhibition formed showed evidence of antibacterial activities (Figure 4). This may be attributed to the modification of eggshells with titanium oxide.

Further to the above, TiO_2 has been reported to be an effective antimicrobial agent that is compatible with the human body or environment [15, 16]. In particular, and in a more recent study, it was demonstrated that titania reduces the ability of bacterial such as Staphylococcus aureus *(S. aureus)* to adhere to surfaces by rupturing their cell membrane [26].

As such, one could attribute the inhibitory properties of EB@TiO_2 to the attachment of titanium oxide (TiO_2) on the surface of the eggshell powder. This is can be supported by the fact eggshell powder alone showed no antibacterial activities whilst the antibacterial activities of TiO_2 was comparable to EB@TiO_2 (Table 1). The plausible explanation for this may be attributed to the fact that the calcium carbonate which is a constituent of eggshells is a poor source of nutrients for microbes to colonise. This is corroborated by Sepehrnia et al. [27], that calcium carbonate inhibits the colonisation of bacteria.

Table I: Inhibitory properties of the samples

Compounds	*E. coli* 25922 (mm)	*B. Cereus* 10876 (mm)
EB@TiO2 (2:1)	6.1±0.5	6.0±0.0
EB@TiO2 (3:1)	6.0±0.0	6.0±0.0
EB@TiO2 (4:1)	6.0±0.0	6.0.±0.0
Eggshell	0.0±0.0	0.0±0.0
Titanium dioxide	6.0±0.0	7±0.0
Colgate Pro-relief	0.0±0.0	0.0±0.0
Sensodyne repair	0.0±0.0	0.0±0.0
Sensodyne rapid relief	0.0±0.0	0.0±0.0
Ciprofloxacin (Control)	18.6±0.5	22.5±1.0

While the slimy extracellular polymeric substances (EPS) produced by dental caries causing bacteria offers it protection and mechanical supports [28], it can be said the abrasiveness of eggshells (since it is mainly calcium carbonates) and the antibacterial properties of TiO^2 could offer robust protection through mechanical removal of biofilms, as well as, rupturing of the cell walls of the bacterial. This is relevant as the calcium carbonates in eggshells will aid in providing the mechanical removal of the biofilms.

Although the inhibitory zones found for EB@TiO_2 against both *Escherichia coli* and *B. Cereus* were lower than that measured Ciprofloxacin (Control), it is, however, higher when compared to the commercially available toothpaste which showed no antimicrobial activities (Table I). The probable reason for this could be that the main active ingredients in the tested toothpaste function mainly act as anti-sensitivity. In reviewing the literature on antibacterial properties of commercially available toothpaste, it was found that the inhibitory zones measured for EB@TiO_2 against Escherichia coli, for example, was higher when compared to the 2.22mm reported for Colgate Salt (Neem) by Dhakal et al. [29]. This thus indicates the antibacterial properties of EB@TiO_2.

While this study provides insight into the antimicrobial activity of the tested EB@TiO_2, certain limitations exist

such as the limited number of tested microorganisms selected for this study. Hence, it may be premature to dismiss the antibacterial properties of commercially available toothpaste. Future study needs to comprehensively assess the antibacterial properties of EB@TiO_2 in conjunction with other ingredients in toothpaste formulations.

CONCLUSION

Oral diseases caused by bacterial is a serious public health concern to the general public. The study showed that modifying eggshell with titanium dioxide increases its antibacterial properties. This is vital towards the use of eggshells as an ingredient in toothpaste formulation. From a public health perspective and environmental sustainability, the study envisages that using eggshell-titanium dioxide in toothpaste formulation will offer a robust strategy in the prevention of oral diseases caused by bacterial and at the same time, acting as a catalyst towards a greener environment.

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Immediately loaded zygomatic implants used for a functional and aesthetic rehabilitation following a combined maxillectomy and rhinectomy

SADJ September 2022, Vol. 77 No. 8 p489 - p495

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ABSTRACT

Malignancies of the nasal vestibule are rare, yet may result in massive destruction of the face if left untreated. The position and extent of the resulting defects is not only a rehabilitative challenge but also a major psychological burden for the patient. This paper describes a technique for designing and fabricating an immediate surgical obturator and nasal prosthesis to help minimize the post-surgical impact following a total rhinectomy and partial maxillectomy procedure in a patient diagnosed with a squamous cell carcinoma of the nasal septum. The restoration consisted of bilateral zygomatic implants attached to a resin framework housing a central magnet.

The latter was used to retain the nasal prosthesis and help support an interim maxillary obturator. Conventional impressions of the dentition and a moulage of the nasal defect were taken. The master casts were poured and used for design and fabrication of the obturator and nasal wax pattern Colour matching of the nose and facial areas was performed with the aid of a digital spectrophotometer (Quickweigh; Spectromatch Ltd., UK), and a silicone nasal prosthesis was fabricated. This case demonstrated how both a functional rehabilitation and reduced psychological impact was achieved by delivering an immediate surgical obturator and facial prosthesis.

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2.	Prof LM Sykes	20%
3.	Dr PT Nethononda	20%
4.	Dr K Naidu	20%

INTRODUCTION

Oral and facial defects following ablative cancer surgery can have profound functional, aesthetic and psychosocial effects that may negatively impact on a patient's quality of life. Malignancies of the nasal vestibule are rare accounting for 9% of cancers of the nasal cavity and <1% of all malignant tumours of the upper aero digestive tract[1]. They occur most commonly in males between the ages of 60 and 65 years. These malignancies behave differently histologically and clinically when compared with tumours arising from the nasal cavity, being more like squamous cell carcinomas of the skin[2]. For this reason, they are considered separately for diagnosis and treatment purposes. Other skin cancers found to also arise in the nasal vestibule include basal cell carcinoma and melanoma, with sun exposure and smoking, listed as risk factors. Research shows that malignancies of the nasal vestibule carry a far more favourable prognosis than malignancies of the posterior nasal cavity or paranasal sinuses, and a slightly worse prognosis than those of the nasal skin[2]. Treatment of these tumours depends on the size and the presence of regional lymph node metastasis. The latter being regarded as a sign of poor prognosis. For small lesions (T1), radiotherapy is the treatment of choice due to superior cosmetic results, whereas surgery is the primary treatment for larger lesions (T2 & T3) where there is cartilage or bone involvement, and is generally followed by radiotherapy[2]. Primary nasal vestibule tumours are usually small at presentation with no evidence of cartilage or bone invasion whereas tumours ≥4 cm in diameter are associated with invasion of the pre-maxilla and usually require extensive surgical resection.[3]

When carrying out surgical procedures in the midfacial region, a clear understanding of the anatomical limitations of the area is needed. The nasal vestibule is a pear-shaped opening in the most anterior portion

of the nasal cavity, and functions as the entrance to the cavity. It is bounded medially by the nasal septum and columella, laterally by the lower lateral nasal cartilage and inferiorly by the premaxilla. The vestibule is separated anatomically from the nasal cavity by the limen nasi, which is the junction of the upper and lower lateral cartilages, and the transition from the skin to the mucosa is lined with skin-bearing hair follicles, sebaceous glands, and sweat glands[2]. The nasal cavity on the other hand, is bounded above by the anterior cranial fossa, laterally by the orbit and the maxillary sinus, and below by the hard palate[4]. These anatomic regions house important structures that include the orbital contents, the pterygopalatine ganglion, and the descending palatine artery.

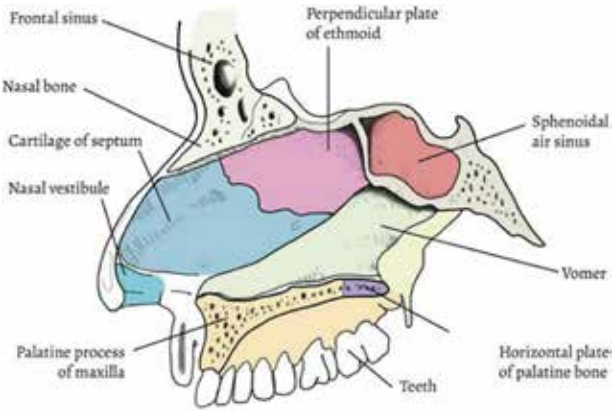

Fig.1 - A sagittal view of the nasal cavity and vestibule
(Downloaded from: Functional Anatomy and Physiology of the Airway. A Mete and I Hatice Akbudak; Accessed at: https://www.intechopen.com/books/tracheal-intubation/functional-anatomy-and-physiology-of-airway

Maxillofacial defects resulting from surgical resection of this area are difficult to treat with conventional prosthodontics due to their location, the lack of suitable supporting bone, and surface lining of friable nasal mucosa. The recent use of zygomatic implants has provided significant benefits for prosthesis retention and speech and masticatory functions[5,6].

This case report describes a technique of designing and fabricating an immediate facial prosthesis for a patient who was diagnosed with squamous cell carcinoma of the nasal septum, in order to minimize the psychological impact following a rhinectomy and partial maxillectomy.

CASE REPORT

A 43-year old female patient diagnosed with a squamous cell carcinoma of the nasal septum, was referred to the multidisciplinary maxillofacial clinic at the University of Pretoria Oral Health Centre for presurgical assessment and management (Fig 2). Computer tomographical spiral axial scans revealed total destruction of the nasal septum as well as the bony nasal floor. During a multidisciplinary treatment planning session, it was decided that the first phase of treatment would be to carry out a total rhinectomy and partial maxillectomy, with immediate placement of bilateral zygomatic implants and provisionalization of the defect. Post-surgical radiotherapy was planned to begin a month later. Pre-surgical prosthetic planning included designing an interim denture which would serve as an obturator, as well as a prefabricated silicone nasal prosthesis with a central magnet that would attach to a reciprocal magnet housed in a resin framework. The framework would then be screw-retained on bilateral zygomatic implants (Zygan® - Southern Implants, South Africa). This treatment protocol would allow for immediate restoration of speech, limited masticatory function and psychological advantages.

Fig. 2 Patient at the time of presentation

Fig. 3 Immediate maxillary denture/obturator

Fig. 4 Impression taking using Body DoubleTM and a plaster of Paris backing

Treatment sequence:

Prior to surgery

Conventional impressions of the dentition were taken using an irreversible hydrocolloid regular set alginate impression material (Blueprint® 20+, Dentsply Sirona,

Fig 5. Moulage impression prior to casting in dental stone

USA). Master casts were poured in Type III dental stone and used to fabricate a surgical stent/interim denture/ obturator was fabricated in clear acrylic. ProtempTM Plus (3M, USA) provisionalizing material was injected into the anterior segment of the clear acrylic obturator, to give an illusion of teeth, and pink acrylic added from the gingival margins to the edges of the denture flange to give an illusion of the gingiva (Fig 3). At the same time a facial moulage was taken using Body DoubleTM (Smooth-On, Inc.,USA), a silicone rubber material that is directly applied in order to make the facial cast (Fig 4). Dental plaster was applied over it to provide a rigid support for the impression (Fig 4). Body DoubleTM is preferred over alginate because it has the ability to reproduce finer detail, and many casts can be produced from one impression. (Fig 5)

The Body DoubleTM cast (Fig 6) was used to sculpt a trial nose and upper lip in pink modelling wax (Tenawax®, Zeta) (Fig7). This was flasked in dental plaster, wax boiled out and packed with layers of pigmented silicone (Fig 8). Colour matching was carried out with the help of a spectrophotometer (Quickweigh; Spectromatch Ltd., Bath, UK). Moulds were clamped together, and excess material removed before the silicone was processed at room temperature.

Thereafter, the silicone nasal prostheses was removed, and excess material trimmed off with a knife and a pair of scissors. A central magnet was embedded on the fitting surface of the nasal prosthesis using a self-cure acrylic resin to assist the patient in orientating and seating of the prosthesis. Considering that the nasal prosthesis would be small and light, it was presumed that this would place little additional load on the implants

Silicones remains the most widely used material for facial prostheses due to their good surface texture and elasticity. They have traditionally been retained with medical adhesives, however several clinical problems have been reported, including allergic skin reactions, wear and tear of the edges of the prostheses, and difficulty in cleaning off residual amounts of adhesive agent. Retention is also poor due to the moisture and mobility of the surrounding skin which may aggravate the delicate surgical margins and facial tissue each time the prosthesis is removed and the glue cleaned off. It is also often too painful to try improve retention by

Fig 6: Final cast poured in Type III dental stone

Fig 7: Wax pattern of the facial prosthesis.

Fig 8: Provisional silicone nasal and facial prosthesis.

extending the prosthesis into soft tissue undercuts in the newly resected mucosal areas.

Surgical phase

A total rhinectomy and partial maxillectomy was performed and frozen sections were taken in theatre to confirm clear margins (Fig 9). Two 30 mm zygomatic implants with 4.0 mm wide restorative platforms were placed bilaterally (Zygan - Southern Implants, South Africa) and used to retain the pre-fabricated resin framework. The interim denture was inserted and

Fig 9: Intraoperative views. A: The resected premaxilla

Fig 10: Surgical obturator positioned prior to being secured with surgical screws

secured in position with trauma screws (Fig 10). The upper lip was then sutured back into position providing some additional support for the obturator.

Restorative phase

During the same surgical procedure, titanium temporary abutment cylinders were fitted on the zygomatic implants. The screw holes were plugged with bone wax to avoid the resin pick up material from clogging the screw access holes. A fast-setting cold cured acrylic resin (Pattern ResinTM LS, GC-America INC, USA) was syringed around the cylinders and moulded into a triangular shape to mimic the shape of the defect. A magnet was positioned centrally to correspond to the position of the reciprocating magnet in the facial prosthesis (Fig 11). Once set, the framework was removed, along with the temporary abutment cylinders. The framework was finished off and

Fig 11: Positioning of the magnet in the acrylic resin superstructure

Fig 12: Placement of the nasal/facial prosthesis

polished and then immediately screwed back onto the zygomatic implants. This allowed the facial prosthesis to be placed before the patient woke up from the general anaesthetic (Fig 12). The patient was recalled at 1 week to check on the surgical site and prostheses prior to being sent for radiotherapy (Figs 13 a and b).

DISCUSSION

Maxillofacial rehabilitation is a challenging aspects of prosthodontics, yet it can play a pivotal role in the aesthetic, functional and psychosocial rehabilitation of

Figs 13 a) and b) Prosthesis in place at the 1-week recall visit.

patients with large head and neck defects[7]. In patients diagnosed with carcinomas of this region, the initial consultation should be by a multidisciplinary team to ensure that the proposed treatment addresses issues of tumour ablation as well as oral rehabilitation. The proposed surgery should attempt to preserve the continuity of as many anatomic structures as possible in order to provide a foundation for restoration with an aesthetic and functional prosthesis. This will contribute greatly to the patient's psychological well-being and quality-of-life[8]. Recent advances in treatment and rehabilitation, particularly in the field of maxillofacial prosthodontics has helped alleviate many of the adverse sequelae of the often disfiguring surgery, and aided in the post-operative restoration of speech and masticatory functions[9].

Treatment planning for the prosthodontic rehabilitation for patients due to undergo any large oral and/or midfacial surgery must involve a multidisciplinary team and be carried out prior to any surgical intervention. This usually necessitates carrying out a comprehensive evaluation in a limited time so as to not delay the surgery, but at the same time aim to optimize their psychosocial and oral health status after surgery. Wherever possible the procedures should strive to maintain as many remaining teeth and oral / facial structures without compromising the success of the surgery[10].

Post-surgical sequelae may include loss of substantial amounts of bone and soft tissue, constriction and collapse of the face and lips, poor aesthetics, impaired speech and mastication, nasal regurgitation of food and liquids and incompetent lip seal[11]. A combination of intraoral surgical obturators and extra oral facial prostheses play a vital role in addressing some of these problems and restoring limited function.

Planning for the oral and /or facial prostheses needs to take into consideration issues of retention. Intra-orally this is accomplished by retention of as many viable teeth and surrounding structures as possible, creation of useable undercuts, and preservation of lip continuity. Extra oral retention poses a bigger problem. Various methods have been used in the past including mechanical attachments such as eyeglasses and magnets, engaging hard and soft tissue undercuts, and the use of medical adhesives.
None of these are ideal.

The use of zygomatic implants in the rehabilitation of these patients has vastly improved treatment outcomes and rehabilitative success. These implants were first introduced as an alternative to bone augmentation in the severely resorbed posterior maxillae, but have since been placed in a number of maxillofacial prosthodontics patients to provide retention for both intra-oral and extra-oral craniofacial prostheses[6]. There are various schools of thought as to the timing of implant placement in oncology patients. However, placement at the time of surgery has gained popularity, as this reduces the need for additional surgical procedures, and there appears to be better survival of the implants if placed prior to radiotherapy. In addition the immediate placement of implants together with delivery of an interim obturator and facial prostheses has major

functional and psychosocial benefits for the patients. For this patient, a combination of zygomatic implants and mechanical retentive mechanisms (resin framework with magnets) were used to retain the maxillary obturator and nasal prosthesis respectively. The magnets within the framework and facial prosthesis are small yet have strong attractive forces which allow for ease of placement, accurate positioning, automatic repositioning, ease of removal for cleaning, and are simple and cheap to replace [12].

CONCLUSIONS

Despite its small size, untreated tumours of the nasal vestibule can spread to involve large areas of the nose and midface which will then require extensive surgical ablation. The resulting defects can have major aesthetic, functional and psychosocial consequences for a patient. This case illustrates the use of immediately loaded zygomatic implants to support and retain a maxillary obturator and facial prosthesis, thus sparing the patient from multiple surgical procedures, and reducing the devastating trauma of the post- resection facial disfigurement.

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Overview of Lithium Disilicate as a restorative material in dentistry

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ABSTRACT

Lithium disilicate was first introduced to the dental field as an indirect restorative material in 1998. It was marketed under the name IPS Empress 2, and was intended for use with press technology. It was later replaced by modified versions including IPS e.max® Press and IPS e.max® CAD. Newer versions have since emerged, namely Amber Mill GC Initial and CEREC Tesseratwo. The latter has part crystal composition of lithium disilicate, embedded in a glassy zirconia matrix. The CAD version is provided in a meta-silicate state, characterised by 40% platelet-shaped lithium meta-silicate crystals and a glassy matrix that is bluish in colour. To obtain the desired lithium disilicate structure and tooth shades, a process of crystallization is required. This involves firing at 840 °C, for 25 minutes. The resulting glass-ceramic material has the benefit of providing maximum aesthetic translucency along with good fracture resistance of about 2MPa, and mechanical strength of 360MPa.

Developments in the all-ceramic dental materials have led to improvements in their physical properties and aesthetic appeal, leading to a substantial increase in their clinical use. This paper present a review of lithium disilicate with particular reference to its chemical composition, aesthetic versatility, and durability for use in crowns, veneers, and implant retained restorations. It also covers the recommended techniques prescribed to ensure predictable bonding and cementation. An electronic literature search on the use of lithium disilicate in dentistry was carried out using EBSCOhost search engine. This included all papers relating to its use for conventional veneers, crowns and bridge work, for CAD/CAM restorations, dentine bonding procedures and luting agents. It covered all papers published in peer reviewed journals from 1988 to 2021. The review indicates that lithium disilicate can be a useful and versatile material in dentistry providing it is handled correctly and the recommended tooth and restoration surface preparations and bonding procedures are carried out. The latter involves tooth etching and silane treatment of the fitting surfaces of restorations prior to cementation to improve adhesion and fracture resistance.

Keywords

Lithium distillate, $Li_2O_5Si_2$, dentine bonding, Ceramic; e.max®; Microstructure Glass ceramic

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LITERATURE REVIEW

The use of ceramics in dentistry dates back to the 19th century, with continued developments and improvements being made in terms of material properties and bonding techniques and materials. The dental ceramics that are currently used include metal-based and metal-free ceramics, layering and press ceramics, and analogue and digitally processed ceramics.[1]

The all-ceramic IPS e.max® system which is a lithium disilicate composition was launched in 2005. This material set new standards in terms of its optical and mechanical performance. It was the first modular, fully integrated all-ceramic system of its kind on the market offering excellent aesthetics, different levels of translucency, and increased strength when used in both press systems and with CAD/CAM technology. This has allowed it to be used for a broad spectrum of dental restoration.[1,2]

Lithium disilicate ($Li_2O_5Si_2$) is a glassy ceramic with an average flexural strength of 400Mpa and a favourable translucency, making it suitable for both anterior and posterior use.[3,4] Press ceramics have been on the market for almost 25 years and are now also available in the form of pressable multi-coloured ingots for highly aesthetic monolithic restorations.[1,2]

$Li_2O_5Si_2$ has many advantages over the traditional metal materials, macromolecule materials, and older ceramics. These include high mechanical and flexural strength, good wear resistance and excellent aesthetics.[5-11] However, despite the advances in adhesive dentistry, long-lasting bonds between indirect

restorations and dentin has remained a challenge.[12] Retrospective studies on success rates of $Li_2O_5Si_2$ ceramic restorations from between three to ten years of follow up, showed survival rates (i.e. restorations that had remained in place without complications) of over 95%, with the monolithic crowns having less reported structural problems than layered crowns.[13-16]

Many studies revealed that a significant part of the restoration success depended on the dental luting technique[17] and treatment of the fitting surface.[18-21] Adhesive cements were shown to help improve retention and fracture resistance[22], While the marginal discrepancy was also affected by the luting agent, the fabrication technique, and the ceramic system used.[16,23]

Satisfactory bond union relies on the restoration being close-fitting, but is further aided by surface modification (surface area enlargement), achieved via etching with hydrofluoric acid (HF). This etching creates a surface roughness that aids mechanical interlocking of the luting substance to the treated surface. A further development in the bonding process between the resin cement and the ceramic restoration surface is the chemical bond created by surface silinisation.[24,25]

The microstructure of $Li_2O_5Si_2$ features a wide bimodal grain size distribution with large rod-like crystals epitaxially grown along with the seed and small crystals nucleated from the glass powder. This unique structure has helped improve the fracture toughness and increase its flexural strength.[26] The coexistence of large rod-like crystals and smaller ones formed by the solid-state reaction of crystal and SiO_2 glass has improved its mechanical properties.[27-32] By controlling the in-situ growth phase via the sintering process of lithium disilicate crowns, some grains grow elongated with a high aspect ratio, thus obtaining the bimodal microstructure similar to that of fibre reinforced composites.[33] This distribution plays a role in deflection and bridging cracks to improve the flexure, strength, and adhesive properties.[22,34] However, due to its intrinsic brittleness and low defect tolerance, the fracture toughness of lithium disilicate is still far less than that of zirconia.[10-15]

Etching

Various different etching regimes have been recommended by different manufacturers. These include etching the fitting surfaces of the restorations with micro brush application of either IPS Ceramic Etching Gel acid HF (4%) or VITA Ceramics etch (5%) for 20 seconds. These agents must then be thoroughly rinsed off with water and air dried. The diluted solution is treated with a neutralising powder composed of sodium and calcium carbonate (IPS Neutralizing Powder, Ivoclar Vivadent) for 5 minutes and placed in an ultrasonic bath. Ultradent recommend etching for 30 s with 35% phosphoric acid, followed by rinsing with water and drying for 5 seconds,[35,36]. Ivoclar advise that IPS e.max® CAD and IPS e.max® Press restorations be etched for 20 seconds with 5% HF.[37] However, Shahverdi et al. found that a combination of sandblasting, HF acid treatment and silane application was the most successful regime.[38]

On the other hand, Guilherme stated that treatments with alumina airborne-particle abrasion alone or etching with 95% HF for 30 seconds improved shear bond strength.[39] However, combining alumina airborne-particle abrasion with different HF etching procedures did not improve shear bond strength and HF alone was sufficient.[39]

Dental restorations in which enamel and dentin were prepared using the total-etch method attained bonds of up to 28Mpa in enamel[40] and 13–20Mpa in dentin.[41]

The bonds achieved with etch and rinse systems are stronger and more predictable on enamel surfaces, while those on exposed dentin show reduced fracture resistance.[42-43] Self-etching primers offer a more simplified bonding protocol and are reported to improve bonding to the dentin, as they etch the surface and penetrate it simultaneously.[44,45] Initial studies suggest that the self-etching primers show promise in terms of improving bonding to dentin,[46] However others have noted that the bond strength mediated by the self-etch primer Monobond Etch and Prime (MEP) was lower than that of the functional silane hydrolyzed3-methacryloxypropyl trimethoxy silane (MPTMS) or Mono Bond Plus with HF technique.[47,48]

Silanes

Silanes are a class of organic molecules that contain one or more silicon atoms (3-methacryloxypropyl trimethoxy silane), which act as a wetting agent and help to form covalent chemical bonds at the involved interfaces. Single-bottle silanes that are pre-hydrolysed typically consist of 1% to 5% silane in a water/ethanol solution with added acetic acid to achieve the desired pH of 4 to 5. They perform optimally if left for 5 minutes. Silane hydrolysis creates terminal hydroxyl groups on each silane molecule. These hydroxyl groups react directly with corresponding hydroxyl groups on the surface of feldspathic porcelain through the oxidation of SiO_2. A condensation polymerization reaction creates bonds between the silane and porcelain when the opposing hydroxyl groups interact with one another via hydrogen and covalent bonding.[49] Clinically, the surface of the porcelain should appear matt after silane application and drying. Once the inorganic end of the silane molecule has bonded to the porcelain, the methacrylate group can bond via free radical addition polymerization with methacrylate groups in the resin. Silica coating is not effective, or required, with $Li_2O_5Si_2$ because significant amounts of SiO_2 and free hydroxyl groups are already present.[4,37]

Cementation

Cementation with zinc phosphate provides mechanical retention and relies heavily on the contour of the prepared tooth and close adaptation of the restoration to provide retention. Clinically this mechanical retention is considered less effective than that obtained with bonding systems.[50] Composite resin cement Rely-X Ultimate in combination with Scotch bond Universal adhesive provided equal mean removal stress as for Multilink Automix used with Multilink Primer, with both generating high crown removal of,2.9 to 3.9 MPa. These all exceeded zinc phosphate cement adherence.[16]

Adhesively cemented dental ceramic crowns have a superior breakage resistance compared to traditionally cemented restorations. However this may also be dependent on the thickness of all-ceramic restorations especially in veneers.[51,53] Occlusal veneers with a thickness of 0.6–1.0 mm and 1.2–1.8 mm can resist forces of up to 800 N and 1000 N respectively.[54-56] In a study by Sasse et al.,[52] the fracture resistance of occlusal veneers made of $Li_2O_5Si_2$ was examined and showed that the thickness of the occlusal veneers should not fall below 0.7–1.0 mm.

Self-adhesive resin cements are used to simplify the technique due to their high viscosity and low etching capacity. The bond strength of self-adhesive resin cements is lower than that of resin cements and adhesive systems. To optimise the bond strength between cements and teeth, surface treatment with different conditioning agents have been suggested. Chlorhexidine is widely used as an antibacterial agent and has a broad antimicrobial spectrum. This solution has an inhibitory effect on the activity of MMP on dentin, which can prevent collagen collapse and the corresponding degradation and disintegration of the bond interface.

Lührs et al. and Shafiei and Memarpour verified a decrease in bond strength values of self-adhesive cements over time. When compared to conventional hydrophobic resin cements, water sorption was higher due to the acidic and hydrophilic character of the self-adhesive cements. Rely X U200 has a lower initial pH (<2) which increases its potential for demineralisation and contributes to higher bond strength if compared to Smart Cem 2. Both agents showed lower bond strength compared to conventional resin cements due to four factors: (1) acidic monomers have low etching capacity, minimising the surface demineralisation; (2) the buffering effect of the minerals present in the dentin can neutralise the pH of the cement; (3) the high viscosity of the cement hinders their penetration into the interfibrillar spaces; (4) non-removal or incomplete removal of the smear layer promotes a weakly bonded reinforced resin intermediate layer. The loss of integrity of the resin-dentin interface during function is affected by thermal, mechanical, and chemical actions. These actions are detrimental to the longevity of indirect restorations luted with resin cement.[12]

For luting $Li_2O_5Si_2$ crowns there are three suggested cement-adhesive combinations that may be used (RelyX Ultimate with Scotch Bond Universal, Monobond S, Multilink Automix with Multilink Primer A and B and NX3 Nexus with OptiBond XTR). All showed good retention (2.9-3.9 MPa; 387-522N) after six months. Cements using their matched dentin bonding agent as the ceramic primer were as successful as cements with a separate silane coupling agent, but self-adhesive resin cements such as U100 showed lower bond strength to dentin than RelyX ARC conventional resin cement.[16,64]

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What's new for the clinician– summaries of recently published papers

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1. The prevalence of SARS-CoV-2 IgG antibodies among dental teams compared to the general population

The Corona pandemic fundamentally changed the world of business, communication, healthcare delivery and infection control in the last 2-3 years. Dentistry, which was already a high-risk category during the HIV pandemic went into a lockdown that saw many practices close or offer very limited non-aerosol generating procedures (non-AGPs) during this period. The science and best practice also changed significantly from an initial period where interventions such as fogging, mandatory testing with the slightest presentation of symptoms, isolation of suspected covid-19 infected patients, etc resulted in closure or limited scope of practice being offered at most private and public facilities. SARS-CoV-2 is mainly transmitted through droplets and aerosol particles.

Aerosols generated during dental procedures, such as osteotomies, drilling, prophylaxis, and ultrasonic scaling, became a focal point with utmost urgency for policy-makers due to the fear of coronavirus transmission. Living coronavirus has been detected in the saliva; thus, dentists and their team were presumed to be highly susceptible due to their frequent occupational exposure to aerosol-generating dental procedures (AGDP) compared to the general population. The question whether the dental team may even be "super spreaders" for the SARS-CoV-2 to their patients was widely discussed and caused major uncertainty. This led regulators and health authorities worldwide to call for postponing elective procedures and provide emergency-only treatment hoping to restrict the spread of the virus.

Mksoud et al (2022)[1] reported on a multi-center study that sought to investigate the risk of infection among the dental team compared to the general population, and clarify the impact of protective measures in preventing SARS-CoV-2 infection.

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MATERIALS AND METHODS

This cross-sectional study involved 2998 individuals who work at licensed private dental practices in Germany between January and April 202.

Participants were recruited from 5 urban regions in Germany:- (1) Berlin, (2) Hamburg, (3) Dresden, (4) Stuttgart, and (5) Cologne/Düsseldorf. In total, 7300 invitations were sent out to participate in this study. Each dental practice was asked to name three designated participants including a dentist, a dental nurse, and a dental prophylaxis nurse. Overall, 3305 participants from 1390 dental practices (equalling 4170 subjects) agreed to participate in this study and gave their written informed consent (response rate 79%).

Each participant received a study package that included a questionnaire and a dry blood collection set (EUROIMMUN), both labelled with the same numerical identifier "ID." IDs were automatically generated prior to sending out the study materials to ensure data privacy and enable the matching of self-reported data with biomaterials afterwards. Participants who did not complete the questionnaire (n=297) or failed to provide a dry blood sample as instructed (n=10) were excluded. By 21 April 2021, 2998 packages were received and included in the study. A total of 200 participants had to be excluded due to vaccination. Furthermore, we excluded 14 participants who reported being previously tested positive for SARS-CoV-2 but no antibodies in their dry blood sample could be detected, thus leaving us with data from 2784 participants.

Participants were asked if they had already suffered from a SARS-CoV-2 infection confirmed by a PCR test, had been vaccinated, or had treated patients positively tested for coronavirus disease. The remaining questions revealed how the practice activity and working hours were affected by the pandemic, the working circumstances in the practice, and implemented personal protective equipment (PPE). The survey encompassed the year 2020 and the answers were given in quarterly periods (Q1: January–March, Q2: April–June, Q3: July–September, Q4: October–December). This study focused on the answers from the second, third, and fourth quarters.

Participants collected a capillary blood sample from the fingertip which were tested for anti-SARS-CoV-2 IgG antibodies. The diagnostic sensitivity of this assay was reported to be 43.7% in samples taken until day 10 after symptom onset or positive direct detection and 94.4% in samples collected after day 10 and specificity was reported to be 99.6%. A participant was considered as having had a SARS-CoV-2 infection if he/she had SARS-CoV-2 antibodies or reported having a positive SARS-CoV-2 PCR test before our study period. Data from 24 individuals with a borderline laboratory finding without reporting a positive SARS-CoV-2 PCR test were set to missing.

For the control population, biospecimens (dry blood sample and a swab sample from the mouth and nose) were collected from a nationwide population sample drawn from the German Socio-Economic Panel (SOEP).

RESULTS

The researchers examined 2784 dental team members from 1125 offices in Germany. They recorded 146 participants with positive SARS-CoV-2 IgG antibodies (5.2%) and 30 subjects with a borderline finding (1.1%). In total, 74 out of the 146 participants with SARS-CoV-2 IgG antibodies did not report a positive SARS-CoV-2 PCR test (50.7%) and 27 participants without SARS-CoV-2 IgG antibodies did report a positive SARS-CoV-2 PCR test (1.1%). When combining the laboratory and self-reported information, the number of participants with a SARS-CoV-2 infection was 179 (6.5%). The frequency of SARS-CoV-2 IgG antibodies was highest in Dresden, followed by Stuttgart and Cologne. In comparison to Hamburg, the risk for SARS-CoV-2 IgG antibodies was significantly higher in Dresden (OR = 6.11; 95% CI: 2.77–13.47; $p < 0.001$), Cologne (OR = 2.73; 95% CI: 1.15–6.48; $p = 0.023$), and Stuttgart (OR = 3.06; 95% CI: 1.21–7.76; $p = 0.018$) but not in Berlin (OR = 1.70; 95% CI: 0.72–4.02; $p = 0.227$).

Usage of filtering face pieces (FFP) masks increased from 48 to 75% from the 2nd to the 4th quarter of 2020, whereas visors and goggles were used regardless of the timeline in 60% and 80% of all participants, respectively. AGDP working time dropped about 3 h from the 28 h/week to 25 h/week from the 1st to 2nd quarter but then increased steadily up to the 4th quarter to reach 29 h/week. The frequency of applying distancing measures was comparable (i.e., about 96%) in all regions

In logistic mixed-effects models adjusted for regions, the risk for a SARS-CoV-2 infection was significantly associated with using a rubber dam (OR = 1.65, 95% CI: 1.01–2.72) and with the number of protective measures (OR = 1.16, 95% CI: 1.01–1.34). No such associations were observed for the other protective equipment or ventilation measures. Age, sex, occupational group, working time with the patient, application of distancing measures, number of aerosol-generating devices, use of ventilation systems, ventilation after each examination, pre-treatment mouthwash, and size of the practice rooms were not significantly associated with a SARS-CoV-2 infection. In a multivariable logistic mixed-effects model including age, sex, occupational group, working time with patient, use of FFP mask, use of visor, use of rubber dam, application of distancing measures, number of aerosol-generating devices, availability of ventilation systems, pre-treatment mouthwash, and size of practice rooms, none of those variables was significantly associated with a SARS-CoV-2 status. Particularly, reported significant association between using a rubber dam and SARS-CoV-2 status attenuated and turned non-significant (OR = 1.44, 95% CI 0.82–2.53; $p = 0.206$).

In the general German population, the cumulative incidence of PCR-validated SARS-CoV-2 infections reported for the time between October 1, 2020, and April 15, 2021, was 5.0% for Dresden, 4.1% for Berlin, 3.4% for Hamburg, 3.7% for Cologne, and 3.5% for Stuttgart. The prevalence of SARS-CoV-2 antibodies was about 3% in January, 6% in February, and 7% in March across Germany.

CONCLUSIONS

The researchers concluded that the risk of SARS-CoV-2 transmission was not higher among the dental team compared to the general population.

Implications for practice: The WHO safety protocols implemented in many practices worldwide has demonstrated a protective effect among the dental team. This has ensured that the risk for acquiring SARS COVID infection among the dental team is similar to that of the general population provided they adhere to recommended infection control protocols.

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2. How have undergraduate dental students' coped with the COVID-19 pandemic?

A novel human coronavirus named severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was first reported in Wuhan Province, China, in late 2019.[1] Within a month, the World Health Organization (WHO) declared the coronavirus (COVID-19) outbreak as a public health emergency of international concern.[2] Due to the disease being highly infectious, together with the ease of transportation and people movement between countries, COVID-19 spread quickly from China to other countries. The WHO recognised the spread of COVID-19 as a pandemic on 11 March 2020, as Italy, Iran, South Korea and Japan reported surging numbers of cases.[3]

South Africa, like much of the rest of the world, introduced severe restrictions in the early days of the pandemic to try and contain the spread of the disease. For dental schools, this meant that there was severe restrictions on face-to-face and clinical activities, especially aerosol generating procedures (AGPs). Internationally, although there is some variation, many dental schools have also suspended clinical teaching and implemented working from home policies.

Dental education programmes are known to be technically and academically extremely demanding. These closures and/or restrcitions resulted in emotional, psychological and physical stress for students, as they had to deal with the demands of time and scheduling pressures, management of difficult patients, examination anxiety and financial commitment.[1] As the country entered the alert level 4, the responsibility fell on academic staff to actively repurpose and redeploy resources, upskill their digital competencies and develop new material to transition traditional face-to-face and blended programmes to a remote learning and/or online education delivery mode.[1] Pandemic crises inadvertently ignite social disruption and mental disturbance such as increased fear and anxiety among the public. Therefore, it may be hypothesised that some dental students who were already stressed due to the demands of the training course may have felt even more emotionally unsettled by the disruptions caused by COVID-19 restrictions, affecting them psychologically, physically and emotionally. Poma and colleagues from New Zealand (2022) [1], which had some of the toughest restrictions in the world, reported on a study that sought to evaluate the impact of the COVID-19 restriction measures on the undergraduate dental students' perception of their physical, mental and social well-being, as well as their financial stress. This study also investigated the students' perceived level of anxiety in relation to their future dental careers.

MATERIALS AND METHODS

An electronic questionnaire was structured using an online platform (Qualtrics) with four main themes related to the ongoing COVID-19 situation as well as the four-week COVID-19 lockdown period. The themes were General well-being, Physical well-being, Psychological and emotional well-being and Behavioural and social well-being

The questionnaire was modelled according to the Depression, Anxiety and Stress Scale (DASS-42)15 and the Perceived Wellness Survey (PWS). Participants were asked to rank their answers according to a 5-level Likert scale (1-strongly disagree, 2-somewhat disagree, 3-neither agree nor disagree, 4-somewhat agree and 5-strongly agree). To allow easier management of results within each theme of the online questionnaire via Qualtrics, any positively worded questions from the PWS were modified with a negative wording approach and followed the general trend of negatively worded questions based on the DASS-42. This meant that lower Likert scale would indicate a positive outcome, whereas the higher Likert scale would indicate a negative outcome. Other questions included demographic information, tuition fee-paying status and living situation during the lockdown period. Free-text comment boxes, which were optional to complete, were also available at the end of each theme for the participants to elaborate further on the answers that they have given.

The online link to the survey was distributed to all undergraduate Bachelor of Dental Surgery (BDS) students (n = 376; Year 2–5) via their email addresses as well as posting it to each class Facebook page. The survey period occurred during a lockdown with alert level 4. Student participation was on a voluntary and anonymous basis and no incentives were used to improve the rate of responses.

RESULTS

There were 301 out of 376 undergraduate dental students (80.1% response rate; 102 males, 198 females, 1 did not want to answer) with a mean age of 22.0 ± 2.70 years (range: 18–40 years) who participated in the survey. The highest response rate was from the BDS Year 5 class (85.6%; 83 out of 97) followed closely by Year 4 (85.1%; 86 out of 101), Year 3 (81.0%; 64 out of 79) and Year 2 (68.7%; 68 out of 99).

There were 211 domestic and 90 international students. For domestic students, a significant proportion was relying on New Zealand government student loans (n = 149; 70.62%) followed by personal loans (n = 5; 2.37%), scholarship (n = 4; 1.90%) and other means such as parents (n = 53; 25.12%). Most of the international students (n = 40; 44.44%) relied on their parents and family support as the main source of funding for their tuition fees, followed by their personal loans (n = 29; 32.22%) and scholarships (n = 21; 23.33%).

During the 4-week lockdown period, the majority of participants decided to stay in Dunedin where the Dental School was located (187 out of 301) while the remaining students returned to their hometowns. Among those who stayed in Dunedin, a significant proportion (71%) were in shared houses with others, while a few students (9 out of 187) moved back with their families in Dunedin.

Approximately a quarter of the respondents (n = 75; 24.9%) were employed in a part-time job during the academic year of 2020. Approximately one-third (n = 24; 32%) of them did not experience any changes with their employment status, while the same proportion (n = 24; 32%) had lost their job

as a result of the COVID-19 lock down and the remaining students had their working hours reduced (n = 27; 36%). Most of the respondents reported no dependents (81.7%). Respondents mainly gained information about COVID-19 through social media such as Facebook or Twitter (32.58%) as well as online government or news websites (36.81%). Less than 1% of the respondents chose not to listen to any information related to COVID-19.

Overall, students perceived their physical well-being as relatively on the positive side (mean Likert score 2.75 ± 0.82). There were insignificant differences between each BDS year levels (Year 2 = 2.98 ± 0.83; Year 3 = 2.64 ± 0.74; Year 4 = 2.74 ± 0.84; Year 5 = 2.65 ± 0.80). In terms of gender differences, there was no significant difference between males (2.68 ± 0.90) and females (2.77 ± 0.77). On average, students reported a similar level of impact on their psychological well-being (2.79 ± 0.62) compared to their physical well-being. There was no statistically significant difference in the psychological and emotional well-being in relation to the year of study. However, female students (2.85 ± 0.60) reported to be more psychologically and emotionally affected compared to their male counterparts (2.67 ± 0.65) (p = 0.011).

On average, students appeared to be more affected (3.20 ± 0.745) in terms of their behavioural changes due to the COVID-19 situation. There was no difference in the behavioural and social well-being of students in relation to the year of study or gender.

On average, students were not too significantly affected in terms of financial concerns (2.74 ± 1.14). There was also no difference when comparing between different years of study or whether the students had a part-time job (2.85 ± 1.20) or not (2.70 ± 1.13). However, there was a statistically significant difference in the financial concerns in relation to the tuition fee-paying status (p = 0.000) as well as the dependent status (p = 0.001).

On average, students were negatively affected by the COVID-19 situation in terms of their future career prospects (3.41 ± 1.20). There was a clear tendency for increase in future career concerns as the respondents were closer to their graduation. The final year BDS class had the highest concerns showing an average of 4.26 on the Likert scale. The most junior BDS class had the lowest Likert score (mean 2.63), indicating that they were not so affected by the COVID-19 situation when it came to their job prospects.

CONCLUSIONS

The study provides valuable information on the impact of COVID-19 pandemic on undergraduate dental students, and areas that the University should consider when providing support to the affected students.

Implications for practice: the COVD-19 pandemic has created the opportunity to be more proactive and prepared to deal with future pandemics effectively and efficiently.

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CPD questionnaire on page 512

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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To extract or not to extract – Felicific calculus to the rescue

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ABSTRACT

Contestations about the most appropriate clinical intervention and preferred treatment modality remains a serious challenge in dental practice. Dentists must straddle a delicate line between coercion, medical paternalism and respecting patient's interests and concerns. This paper explores a moral debate using a dental extraction case study, and felicific calculus as a tool for joint decision-making. We argue that this instrument offers an invaluable opportunity for building rapport and mutual engagement. Additionally, recognition of patient's preferences must also be considered in the proposed clinical intervention to inculcate a sense of ownership of the interventions proposed for and by the patient. It is argued that, this will instill a sense of shared-decision making in the interaction between the patient and the clinician.

Keywords: utilitarianism, hedonism, felicific calculus, dental extraction, ethics, shared decision-making

INTRODUCTION

Dental extractions are the standard treatment for dental pain in most poor to developing countries including South Africa.[1] Several reasons have been advanced for this widespread occurrence. First, the public oral health services in these regions are under-resourced to offer appropriate alternatives.[2] Second, regrettably, some dental professionals refuse to provide the necessary complex restorative dental interventions. Third, unfortunately, a significant number of patients still believe that dental extractions are by far the most effective treatment for dental problems including pain. Fourth, the demand for extractions has been socialised and deeply entrenched in some communities. This phenomenon is proving very difficult to dismantle and reverse.[3]

The literature indicates that dentists are occasionally 'forced' to provide dental extractions for religious, financial and cultural reasons.[4,5] Acceding to such requests can be deemed unethical and not based on established best practice or common standards of care. Notwithstanding the immense pressure placed on dentists, it is 'inexcusable' to extract teeth without due consideration of the physical, emotional, social and health implications of this irreversible procedure, to the affected patient(s). It is incumbent and prudent for dental practitioners to evaluate and discuss the degree of good, or happiness or utility that dental extractions can confer, before undertaking the procedure.

This paper explores the moral basis for the provision of dental extractions, with specific emphasis on the utility of this procedure. In other words, it seeks to elucidate whether dental extractions maximise the attainment of pleasure and minimisation of displeasure. Pertinent questions to this moral debate include the following: (i) whose utility matters or whose happiness is paramount? (ii) how is the utility of dental extractions estimated? (iii) is the measure used for this estimation appropriate? In other words, should the enumeration of utility be based on the clinician's normative needs or patient's needs and preferences or both? When confronted with a conflict of these interests, which is often the case, how should this moral dilemma be resolved?

CASE STUDY

A 36-year-old patient requested extractions of several teeth from Dr. Mogale, who was unwilling to perform the procedure. Mrs. Morake's oral health status is overall sound, with restorable dental cavities and a mild periodontal inflammatory condition that is reversible. The patient's dental history includes previously failed endodontic treatment and subsequent extractions of unrestorable teeth. She does not use the dentures she had previously made anymore. Dr Mogale referred the patient to a colleague (Dr. Mothudi) based about 85 kilometers away, who was willing to accede to the patient's request.

Brief Review of Utilitarianism

Utilitarianism is a consequentialist moral approach, rooted in the belief that moral rightness is dependent on the consequences of the act or rule and nothing

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else.[6] This philosophical view emphasises the maximisation of benefits or outcomes. As Bentham and Mill advocated, an act or rule is morally right, if and only if, it results in 'the greatest happiness for the greatest number'.[7] According to consequentialism, actions are mere instruments for doing good, thus are intrinsically neither right nor wrong. Given that actions are morally neutral, it is prudent to judge actions as being more or less efficient or useful in bringing about good or an amount of utility, than to assign them moral value.[8] Strict utilitarians believe that moral judgement should be passed on the outcomes or consequences of actions insofar as they maximise happiness and minimise unhappiness.

The analysis of moral questions about consequences requires clarity about the nature and the extent of the value of consequence or utility. It is hence critical to clearly define these two distinct aspects of consequences as a means to fully account for the utility of any actions, programs or policies.

First, the nature of the consequence, seeks to elucidate the following questions:

1. Are the consequences actual, probable, hypothetical or foreseeable?
2. Are the consequences directly due to the act or indirectly due to the rule or practice that incorporates the act itself?
3. Does the action result in the best or satisfactory outcome or a mere improvement?
4. Do these consequences represent total or net good versus average good?

Second, the extent of the consequence, which represents the total amount of utility, or the cumulative sum of pleasures experienced by an individual or groups due to a specific action. A specific question to address this aspect is whether the action applies universally to all persons or is confined only to an individual? This lack of clarity on the nature and extent of the consequence could invalidate the quantification and evaluation of the utility of the consequences. Consequently, the rightness or wrongness of the action(s) and its propensity to maximise utility could be misrepresented. These two aspects of consequences constitute the value or utility of the action. This is by far the most debatable and difficult concept to formulate and measure.

Conceptualisation of utility

Several formulations of utility have been proposed giving rise to diverse accounts of utilitarianism. The earliest and simplest formulation of utility encapsulates the hedonistic nature of 'happiness' or good. The ethical theory of hedonism, purports that pleasure is the highest good, which is intrinsically valuable than pain. Therefore, causing happiness and minimising pain maximises utility of an action – hedonistic utilitarianism. According to Bentham *'Nature has placed mankind under the governance of two sovereign masters, pain and pleasure. It is for them alone to point out what we ought to do, as well as to determine what we shall do. On the one hand the standard of right and wrong, on the other the chain of causes and effects, are fastened to their throne'.*[9,10] Bentham further describes the value or utility *'as the property of any object, or act or policy to produce benefits, advantage, good or happiness. At the same time, the act will prevent suffering, pain, evil or unhappiness to an individual or communities*.' [10]

Under any circumstance, what would the greatest happiness for the greatest number be? How would one's happiness or unhappiness be measured and distinguished from the next person's good or pain? The assessment of utility has largely been intuitive and subject to several formulations to develop some form of mathematical measure or calculus. The concept of hedonistic or felicific calculus remains subjective, difficult to enumerate and standardise. Economists are credited with developing reasonable measures and applications of utility in healthcare. Notwithstanding measures of program utility such as cost-effectiveness analysis, cost-benefit analysis and cost-utility analysis, contingent valuation is most preferred in measuring willingness to receive or pay for a health service based on its attributes.[11]

The contingent valuation measure estimates the value that the patient places attributes of the health system and service.[11] Most valuation methods are primarily comparative, and provide rankings of desired preferences by assigning superiority of one attribute compared to another. These methodologies fail to provide a direct estimate of the nature and extent of pleasure due to an action or utility. Several iterations have not rescued the development of an objective utilitarian calculus, especially about clinical care.

Felicific or hedonistic calculus

Hence to know what men will do, to tell what they should do, or to value what they have done, one must be able to measure varying "lots" of pleasure or pain. How are such measurements to be made?[10]

This Benthamian proposition is a quasi-mathematical technique used to determine the net amount of utility or good produced by an action or policy.[10] In its simplest form, utility equates to the differences in net sum of pleasures and net loss of pleasure (or suffering) due to the action or intervention. Net utility equals net utility produced minus net utility lost; happiness over unhappiness or pleasure over displeasure. To fully enumerate utility, seven aspects of a pleasurable or (un) pleasurable experience are considered:

1. Intensity refers to the magnitude or degree of pain or unhappiness experienced due to the action. The corollary is that, intensity estimates the degree of relief or happiness in the absence of painful activity or occurrence. In the case of dental extractions, intensity estimates the degree of pain relief following the extraction of the offending tooth.
2. Duration indicates how long the pleasure will last, or the displeasure will persist following the activity. In the case of a patient requiring a dental extraction, duration indicates how long the pain persists if the extraction is not done or how long the relief lasts after an extraction is performed.

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3. Certainty, appraises the probability that the pleasure will occur or displeasure abate. In other words, what is the likelihood that there will be pain relief or pleasure following dental extractions? How likely is the displeasure to continue if the dental extraction is not performed?
4. Propinquity or remoteness, indicates the proximity of the experience of pleasure or happiness following the action. It can therefore be asked - how soon after the activity will one experience reprieve from unhappiness? How soon after a dental extraction, will one enjoy a pain free, pleasurable experience? Ceteris paribus, the immediate onset of pleasure is more preferable. Similarly, the immediate relief of displeasure is desirable.
5. Fecundity or fruitfulness measures the extent to which the action will increase the likelihood of experiencing more pleasures of the same type in the future. What is the likelihood of the action producing further pleasures? Will extractions increase the likelihood of experiencing other pleasures; this could include the ability to eat, speak, associate, social interaction etc.
6. Purity is the degree to which the pleasures are not accompanied by displeasure or pain. What is the likelihood that comfort of dental extractions will result in undesirable effects or complications? What other negative consequences will be associated with the act?
7. Extent refers to the number of people who will be affected by the action. While dental extractions are performed on an individual, how many other persons are directly or indirectly impacted by the decision to extract or not to extract?

Case Discussion

The balance between the patients' interests and preferences with good clinical practice is capricious and difficult to attain, never mind entertain. Clinicians are generally determined on achieving satisfactory clinical results, despite strong objections from patients. Some level of medical paternalism can be justified in situations where patients are legally and morally incompetent. Yet, patient's preferences are generally disregarded despite demonstrable agency, all in the pursuit of quality care for patients. The above case study shows differences in the clinical judgment by two dentists. Assuming comparability in expertise, skills and experience, how can such a diverse clinical decision on the same patient be explained? The incorporation of patients' preferences to this trifactor adds another level of complexity to this clinical dilemma.

We argue in this paper that while these two diametrical opposed positions are clinically and morally defensible, they are rooted in experience; preference; predictability and the comfort of the 'tried and tested'. Such judgements are recalcitrant to the exploration of alternative viewpoints and oblivious to the concept of shared or common decision-making. We further assert that joint or collective understanding of happiness and good is plausible and possible in clinical settings. We suggest that hedonistic utility provides an alternative mechanism to resolving this eternal impasse. In this argument, we invoke the utilitarian moral argument, specifically the felicific calculus to analyse the moral dilemma using dental extractions as an example.

The Experiment

These findings represent, a pilot of ten participants (5 dentists and 5 patients) who consented to be part of this experiment and completed a questionnaire (the Hedonistic Calculus Tool) about dental extractions. The participants indicated their views about the pleasure or relief of displeasure as a result of a dental extraction. The six questions of the calculus were assessed using the modified visual analog scale. The scores of between 1 and 10 represented no pleasure to greatest pleasure ever. Table 1 shows, the mean scores and statistical differences between the two groups. It should be noted that this pilot should not be misconstrued as having achieved unquestionable statistical and methodological validity. This is a case study, using pilot data. This case study is based on real -life data, which despite its limited generalisability highlight variances in the viewpoints of dentists and patients than a fictitious case study.

The findings

Patients were on average happier with dental extractions compared to dentists: mean scores 7.30 and 5.63 respectively. This difference was not statistically significant (p=0.200). This result indicates that on average, patients prefer dental extractions, compared to dentists. Several reasons offer a cogent explanation of this phenomenon. For example, socialisation and enculturation of dental extractions, socio-economic factors, and limited treatment alternatives in under-resourced oral health services exacerbate rates of dental extractions.[12,13] The intensity of happiness or relief of displeasure due to dental extraction was significantly different between the two groups (p=0.012). Patients' articulation of pain and subsequent happiness was comparatively precise and proportionate, as it reflected their lived experience. Dentists tended to underestimate the intensity and duration of happiness (3.80 and 5.00 versus 9.00 and 7.00). It is plausible that dentists might be desensitised to the patients' experiences due to their countless clinical interactions with patients.

According to Table 1, the scores for fecundity were 6.20 and 4.40 for patients and dentists respectively. We argue that these scores show critical differences about

Table 1: Hedonistic calculus about dental extractions (dentists and patients)

	Mean score		
Felicific Calculus	Clinician	Patient	p-value
Intensity	3.80	9.00	0.012**
Duration	5.00	7.00	0.266*
Certainty	6.20	7.20	0.517†
Propinquity	7.00	7.60	0.672†
Fecundity	4.40	6.20	0.329*
Purity	7.40	6.80	0.782†
Average Score	5.63	7.30	0.200*
Total Score	33.80	43.80	0.194*

** Statistically significant * clinically different † no difference

what constitutes the positive consequences of dental extractions. For the majority of patients, dental pain is an unnecessary distraction and an impediment to achieving social, economic, cultural and other related aspects of happiness.[14] The sooner, the offending tooth is managed clinically, with assurance of long –term relief, the better for patients. On the contrary, dentists, are likely to view dental extraction along a clinical axis, without due consideration of non-clinical events. This asymmetry in the perception and experience of a clinical phenomenon could be the cause of conflict and contestation between the parties.

There was, however, consensus about the certainty and immediacy of pain relief following extractions, as well as the deleterious consequences of this procedure. These findings indicate that both parties are agreeable about the certainty of pain relief that dental extractions offer, especially in the short term. In the long term, there is commonality about the negative consequences associated with dental extractions. This is evidence of critical levels of shared knowledge and an opportunity for inclusive dialog and discussion.

DISCUSSION

Can the felicific calculus rescue this clinical and moral impasse? The application of the felicific calculus in clinical decision-making compels the patient and dentist to use the same yardstick to assess the consequences of the intended action. By focusing sequentially and intentionally on all aspects of the calculus, critical insight can be gathered on what is the actual crux of the clinical intervention. Contrary to seemingly polarised positions, evidence above suggests areas of congruence, which if jointly identified and explored can accelerate shared decision-making.

This experiment shows that there were no significant differences in views regarding propinquity and purity. From the onset, the clinician can leverage and exploit these similarities in the discussion with patients, about the best treatment modality of care. The dentist is able, from this point of common understanding, to have a meaningful, respectful and deeper engagement with the patient.

Discussions of these nature are empowering, and empathetic, and epitomise Kantian categorical moral imperative for clinicians to *"act in such a way that you always treat humanity whether in your own person or in the person of any other never simply as a means but always at the same time as an ends".*[15]

Simply put, it is incumbent on dentists "to treat others not only as means to an end but as ends in themselves".[16] Deliberate and specific patient engagement is likely to build rapport, close the dentist-patient divide, and ultimately facilitate honest and transparent discussions on clinical interventions and care. Patients who are heard respond positively to the doctor's instructions, and are likely to follow given instructions.[17] Dentists have a prima facie duty to consider the patients' concerns and preferences, with the view to incorporate them into the treatment plan. Anything less is tantamount to paternalism and a blatant disregard for true, full or sufficient patient consent.

This experiment, attempted to present a mechanism to facilitate discussions about a common clinical dilemma and polarised viewpoints. Dentists are trained to provide expert opinion about appropriate interventions, based on best evidence and other considerations. Patients, on the other hand, know best how they feel, and how the treatment works in the absence of the dentist. It is incumbent on clinicians to consider the non-biological basis of the effects of the interventions they provide, more so, the non-clinical consequences of these interventions that the patients might not prefer. The basis of this ethical discussion is based on the pilot of 10 participants which could render the study susceptible to random error. In defense of this research work, the authors, are making moral assertions and not a purely quantitative argument.

CONCLUSION

The use of a felicific calculus in clinical practice can offer valuable insights, by highlighting the biases that clinicians and patients have about the proposed intervention(s). Deliberate interrogation of the felicific calculus findings can serve as a starting point for respectful and mutual discussion about the most appropriate treatment, which incorporates clinical and non-clinical factors. The fusion of mathematics and morality may be used successfully in resolving weighty clinical dilemmas.

Conflict of Interest

All the authors declare that the study was conducted in the absence of any financial relationships that could be construed as a potential conflict of interest.

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Maxillofacial Radiology 203

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C Smit[1], R Potgieter[2]

CASE

A 19-year-old male patient, known with a diagnosis of neurofibromatosis type 1, presented with a plexiform neurofibroma involving the left orbit, zygoma, temporal, and parotid regions. The patient reported a history of left eye enucleation 7-years-ago. What are the pertinent radiologic findings? (Figs.1 and 2)

Fig.1: Panoramic radiograph

INTERPRETATION

The panoramic radiograph shows extensive displacement of teeth and bony components on the left side. There is extensive expansion of the lingula, the entry point of the inferior alveolar nerve into the mandible. Additionally, there is expansion of the infratemporal fossa region and inferior displacement of the left zygomatic arch. An incidental finding of an impacted canine obstructed by a compound odontoma can also be appreciated in the right anterior mandible. Magnetic resonance imaging (MRI) showed an extensive lobulated T_2 / STIR hyperintense mass involving the left orbit, infratemporal fossa, masseter, parotid, carotid and posterior cervical spaces. The lesion demonstrated central areas of hypointensity within the lobules, consistent with a characteristic target sign.

Neurofibromatosis type 1 (NF1) is an autosomal dominant disorder caused by the mutation of the *NF1* gene that encodes for the protein neurofibromin, a tumour suppressor gene. Patients with this condition frequently present with multiple benign peripheral nerve sheath tumors called neurofibromas. A subtype, plexiform neurofibroma (PN), presents clinically with a so-called 'bag of worms' consistency which is essentially pathognomonic of the syndrome and presents with more extensive nerve plexus involvement. PNs are seen in 17% of patients with *NF1* and are frequently diagnosed

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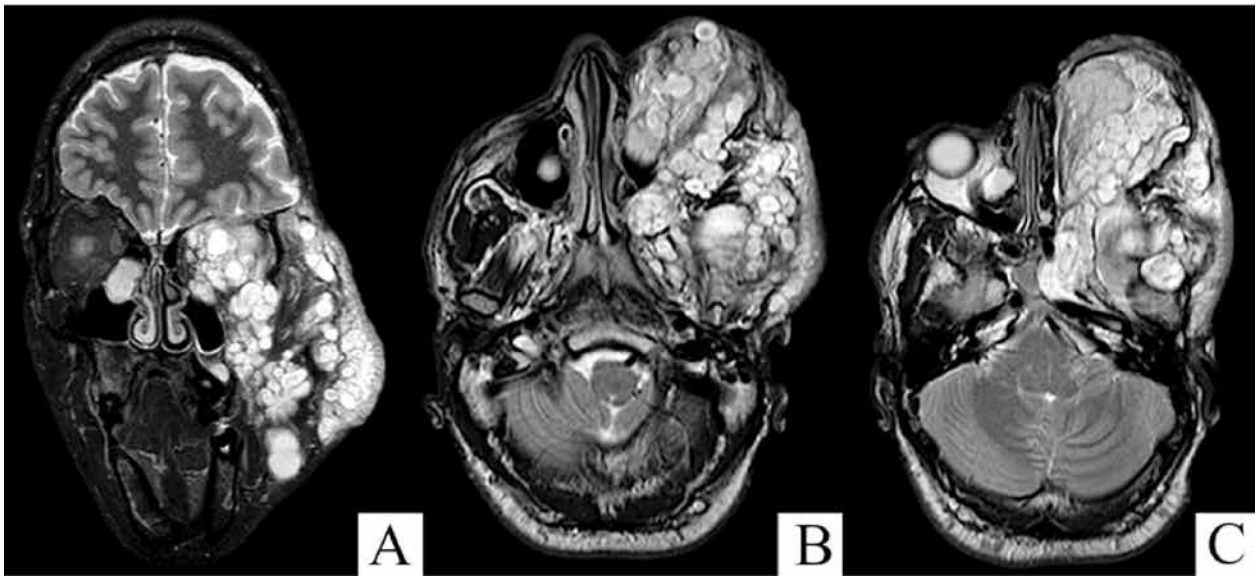

Fig.2: (A) Coronal short-T_I Inversion Recovery (STIR) and (B,C) axial T_2W MRI images

during the first decade of life.[1] They frequently occur on the trunk (43%), followed by the head and neck region (42%) and the limbs (15%).[1] Patients can often present with multiple plexiform neurofibromas[1,2,3], with 42% of head and neck lesions affecting the orbit.[1] Accompanying symptoms are related to mass effect, including loss of function and associated pain in the affected region.[1]

Radiologically, PNs present with three growth patterns: not superficial, displacing and invasive. Superficial growth is seen in 25% of cases and is located on the skin or subcutaneously without muscle penetration.[2] Displacing growth is seen in 26% of cases and presents with a well-defined multinodular appearance that displaces and compresses adjacent structures.[2] The invasive pattern is seen in 49% of cases and penetrates into joints, muscles and surrounding structures with a multinodular appearance and poorly-defined borders.[2] The volume of PNs can range between 76ml and 3703ml in size, which may be accurately detected by automated methods on MRI imaging.[4]

The significance of the identification of plexiform neurofibromas includes a potential for malignant transformation (3%), commonly seen in the displacing and invasive growth patterns.[1,2] Roughly 54% of the invasive growth patterns are seen in the head and neck area.[2] The management of patients with *NF1* includes family genetic consultation, close clinical follow-up of lesions, and surgical removal of lesions that result in aesthetic or functional impairment.[1] Due to the extensive nature of these lesions, complete surgical resection is not possible in all cases. Median tumour progression is 0.6% per year after surgery, with a higher growth rate noted in young individuals.[5] The assessment of the lesion size in cases of PN on MRI is advantageous in the monitoring of residual tumours and novel medical treatments.[4]

Authors declaration

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CPD questionnaire

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GENERAL

Design of removable partial dentures fabricated in dental laboratories serving private and public health dental clinics in the district of Ekurhuleni, Gauteng province.

1. Select the CORRECT answer. In the study by Farao and Geerts (2020), what percentage of acrylic partial dentures had no rests?
   A. 45%
   B. 55%
   C. 65%
   D. 85%

2. Which of the following statements is INCORRECT. Which of the following design principles was NOT included in the study?
   A. Provision of denture design drawings by dentists and/or dental technicians
   B. The material used for the master cast
   C. The presence or absence of prepared rest seats on the master casts
   D. Evidence of casts having been surveyed by the dentists and/or dental technicians

3. With respect to rest seats on posterior teeth, which of the following statements is CORRECT?
   A. Radiograph should be taken prior to preparing a rest seat
   B. Not all teeth to receive rests need to have a prepared rest seat
   C. It is not possible to use rests in an acrylic based partial denture
   D. Rest seats should be prepared to a given shape and set of dimensions

4. Select the CORRECT answer. In this study, how many casts had evidence of prepared rests on the teeth?
   A. 10.
   B. 25
   C. 4
   D. 0

5. In this paper, and from the literature, which of the following statements should be considered CORRECT?
   A. The dental technician should always design the partial denture
   B. The partial denture should include as many clasps as possible to improve retention
   C. Not all partial dentures need to have tooth support
   D. It is the clinician's responsibility to submit a design to the technician

Pharmaceutical cost implications for oral healthcare interventions at a dental clinic in Windhoek, Namibia

6. Select the CORRECT answer. What was the main aim of this study?
   A. To raise awareness on dental health
   B. To help raise funds for children with dental problems in Namibia
   C. To report on the prevalence of different types of oral health diseases amongst dental patients in Windhoek and quantify the pharmaceutical expenditure incurred.
   D. To document the number of deaths due to dental caries

7. Which answer is CORRECT. At which hospital was the dental clinic in this study?
   A. Walvis bay state hospital
   B. Rundu Intermediate Referral Hospital
   C. Katutura Intermediate Referral Hospital
   D. Windhoek Central Hospital

8. Which option is CORRECT. How much of the hospital's annual pharmaceutical expenditure was found to be spent on treatment of dental caries?
   A. 0.4%
   B. 94.6%
   C. 90.1%
   D. 68.2%

9. Select the CORRECT answer. Which age group was found to have the highest prevalence of dental caries?
   A. 1-12 years
   B. 13-19 years
   C. 20-64 years
   D. 65 years and above

Internationalization of an external examiner during the Covid-19 pandemic – The challenges and successes

10. Select the CORRECT option. Making use of external moderators during the examination process:
   A. Improves the validity of the examination.
   B. Ensures the reliability of the examination
   C. Improves fairness
   D. All of the above

11. Which option is CORRECT. Using a combination of written and case-based examinations:
   A. Improves student learning
   B. Improves content validity of the examination
   C. Decreases the assessment load
   D. All of the above

12. Which answer is CORRECT. Consequential validity is heavily dependent on:
   A. Student learning styles
   B. Content validity
   C. Blueprinting of content
   D. All of the above

Overview of lithium disilicate: materials and predictable cementation technique

13. Select the CORRECT option to complete the statement. Lithium Disilicate is
   A. A matte ceramic with a flexural strength of average 400 Mpa and favourable translucency indicate for anterior and posterior use
   B. A glassy ceramic with a flexural strength of average 150 Mpa
   C. A matte ceramic with flexural strength of average 400 Mpa and favourable translucency indicate for anterior use
   D. None of the above

14. Which sentence is CORRECT, In clinical conditions
   A. Mechanical retention is considered adequate for bonding against newer bonding systems
   B. Mechanical retention is considered inadequate for bonding against newer bonding systems
   C. Bonding systems perform ideal and optimal on dentine surfaces
   D. Bonding systems are all interchangeable

15. Which of the following statements is CORRECT. Which interfaces are created during luting
   A. Between the cement and restoration and the dental surfaces
   B. Between the cement and restoration and the adhesive system and the dental surface
   C. Between the dentinal tubules fluid and hybrid layer
   D. Between dentino-enamel junction and mantle dentine

16. Select the CORRECT option. The technique with the most dependable adhesion values consists of:
   A. Tricarboxylic acid and silane.
   B. Hydrofluoric acid and silane
   C. Phosphoric acid and silane
   D. Tridecylic acid and silane

17. Select the CORRECT statement. Silanes are
   A. Class of organic molecules containing one or more silicon atoms
   B. Decomposes and generates hydrogen fluoride gas
   C. Contains a carboxyl group (C(=O)OH) attached to an R-group
   D. Silanols form in the presence of hypohydration and hydrolyzable alkoxy groups

What's new for the clinician – summaries of recently published papers

18. Select the CORRECT answer. In the Mksoud et al study, the combined prevalence (laboratory and self-reported information) of SARS-CoV-2 infection was:
   A. 5.2%
   B. 1.1%
   C. 6.5%.
   D. 50.7%

19. Which of the following is CORRECT. In the Mksoud et al study, the risk for a SARS-CoV-2 infection was significantly associated with:
   A. working time with the patient
   B. use of ventilation systems
   C. using a rubber dam
   D. age

20. Which of the following is CORRECT. In the Poma et al study, which of the BDS class was most negatively affected by the variable "future career prospects"?
   A. BDS final year class
   B. BDS 4 class
   C. BDS 3 class
   D. BDS 2 class

Ethics: To extract or not to extract – Felicific calculus to the rescue.

21. Select the CORRECT answer. Felicific calculus is based on which moral theory
   A. Consequentialism
   B. Deontology
   C. Virtue ethics
   D. Rawlsian theory of justice
   E. All of the above

22. Which of the following is CORRECT. Which philosopher can be credited for the felicific calculus
   A. Jeremy Bentham
   B. Start Mill
   C. John Rawls
   D. Immanuel Kant
   E. All of the above

CPD questionnaire

23. Choose the CORRECT option. Felicific calculus
    - A. is a quasi-mathematical technique
    - B. estimates the net happiness or displeasure
    - C. can highlight areas of common understanding and disagreement
    - D. could be used as a starting point for inclusive discussion
    - E. all of the above

24. Select the CORRECT option. Dentists and patients disagree of the following aspects of the calculus
    - A. intensity and duration
    - B. certainty and propinquity
    - C. fecundity and purity
    - D. extent and magnitude
    - E. all of the above

25. Which of the following is CORRECT. The application of the felicific calculus in clinical decision-making
    - A. compels the patient and dentist to use the same yardstick to assess the consequences of the intended action.
    - B. provides, critical insights on what is the actual crux of the clinical intervention.
    - C. Enables the incorporation of clinical and non-clinical factors in treatment considerations
    - D. Ethical and effective in enhancing patient's autonomy
    - E. All of the above.

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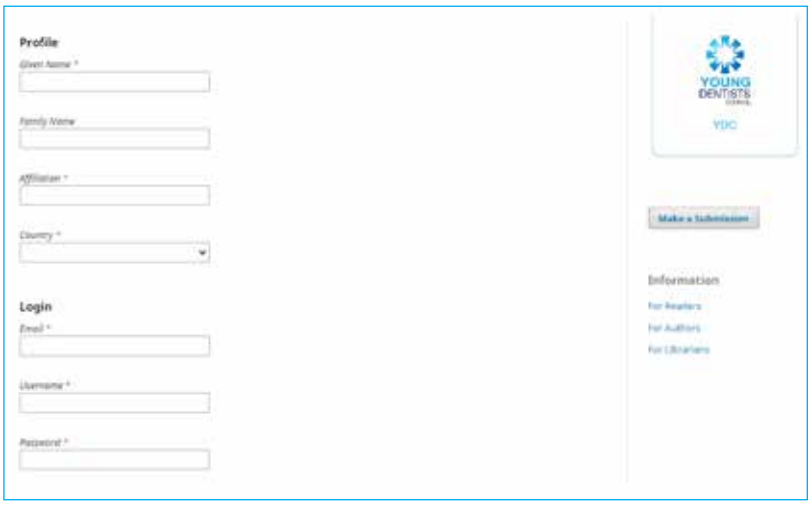

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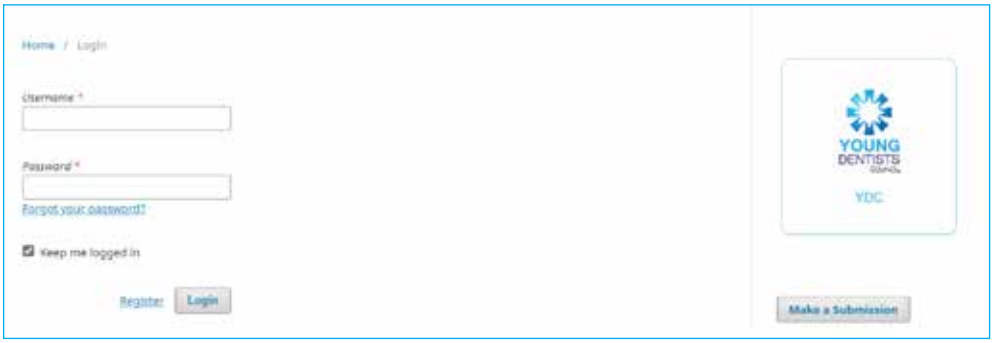

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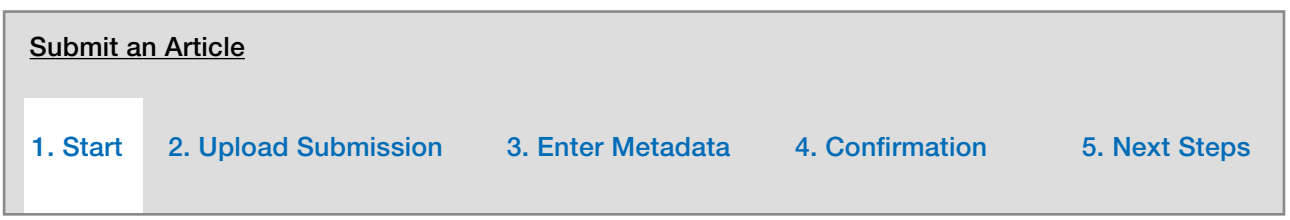

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Author's Checklist

1	Have you read the Instructions to Authors?
2	Are you submitting electronically?
3	Have you provided all author information including first names, affiliations, qualifications, positions held, Department and Institution, ORCID number, contact details?
4	Is the first author under the age of 35 on submission of the article?
5	Have you provided all details of the Communicating Author?
6	Have you submitted questions for the CPD section? (four or five multiple choice, one correct answer)?
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9	Have you submitted the Clearance Certificate number when Ethical permission has been required to undertake research or to publish data?
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11	Are the references quoted according to Journal policy, both in the text and in the list of references?
12	Have all authors signed the Letter of Submission?

NOTES

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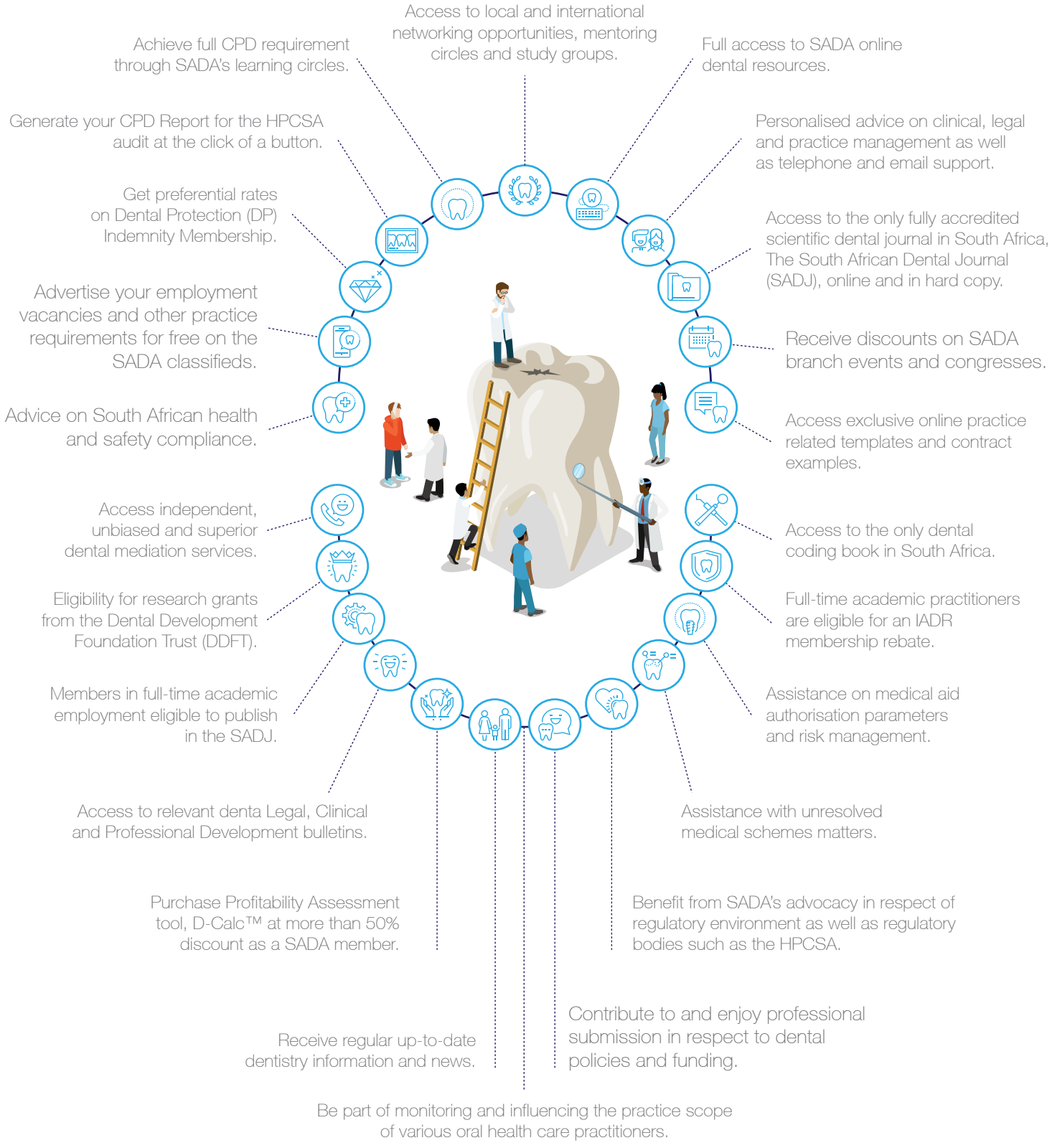

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