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At the root of it all

At first the infant, Mewling and puking in the nurse’s arms. (The Seven Ages of Man: As You Like it, Act 11)

Was Shakespeare acknowledging the travails suffered by infants during tooth eruption? Or at least thought by many that infants do suffer? Eruption of the deciduous teeth traditionally has been blamed for a surprising galaxy of afflictions, including fever, diarrhoea, vomiting, seizures, tetanus, meningitis… and even death! Yet the scientific evidence for such serious problems is lacking and present opinion agrees that any concurrence is incidental, with other causes being responsible. However, the issue of pain associated with eruption is not so readily disputed, and indeed may be due to the stimulation of nociceptive receptors by inflammatory mediators associated with the resorptive processes necessary for tooth eruption. Of course the problem is that the infant cannot communicate except by “mewling and puking” and adults are left to assume the origin of the unhappiness. The most convenient is… teething.

So not only do we not fully understand the possible occurrence of pain, but almost more surprisingly, the mechanisms of tooth eruption have not been completely resolved. Most certainly considerable progress has been made with the advent into dental research of molecular medicine and we are indebted to our authors Nel, Hendrik, Boy and Raubenheimer for a succinct paper dealing with the latest advances in unravelling the process… a common enough physiological sequence and yet still beyond our explanation!

Dental Research is challenged by this... and by many other presently obscure and yet frequent natural processes. The detailed factors controlling growth and development are under intense scrutiny... but to the uninitiated observer, it appears that every unravelling of a process uncovers yet more complexities, variations and yes, redundancies. Why should there be so many repetitions and different options to achieving the same outcome? The application of stem cells in Dentistry seems to offer huge opportunities... but we also seem to be on our first faltering footsteps in realising the potential. How can the biology of tooth movement be so dissected that any component part or sequence may be hamstrung to enhance the achievement of more rapid orthodontics? Improved healing and repair of tissues stands to benefit all our surgical interventions... if only the process could be rendered to a simplicity which would yield to control by the clinician.

To those at the cutting edge of research projects there may only be accolades and encouragement. It is they who will be providing the answers and the guidelines sought by Dentistry in the quest to improve yet further the achievement of the Dental Health Care team.

The profession as a whole carries a responsibility to participate… clinical observation, proper records, follow up investigations are positive actions which can be taken in every clinic or practice. Direct support for research from the profession through the Association has long been an important encouragement to research. Indeed we have passed beyond the Shakespeare description of the reluctant learner:

Then, the whining school-boy with his satchel
And shining morning face, creeping like a snail
Unwillingly to school.

And can claim with justification to “play our part” as he eloquently illustrates in the fifth age of man:

And then, the justice,
In fair round belly, with a good capon lin’d,
With eyes severe, and beard of formal cut,
Full of wise saws, and modern instances,
And so he plays his part.
For our purposes read “dentist” for “justice” and excuse the reference to “fair round belly”!

By coincidence the Journal has been using Medicinal Plants as pictures for our Front Cover. Consider then the similarity of the challenges of root growth in Botany and root growth in Odontology. Both roots must penetrate substances as they extend, both must properly grow in a specific direction. In plants the root tip is covered by a Root Cap, a protective mechanism which sheds cells as abrasion against soil is encountered. Deeper into the root is the area of active growth, the meristem. In teeth the equivalent of the Root Cap is the Epithelial Root Sheath (previously referred to as Hertwig’s root sheath), which is claimed to play more of a role in root formation than serving any protective function. Removal of the Root Cap affected root growth and penetration into compact soil. Plants have an additional tool to ease the path of the growing root…. mucilage is secreted by the root cap to lubricate adjacent soil particles.

At the root of it all, Dentistry needs to continuously lubricate the wheels of Dental Research … may it never be that our endeavours reach Shakespeare’s seventh age… Sans teeth, sans eyes, sans taste, sans everything.’

Reference

ACCOLADE

Recognition of Professors Bookhan and de Wet.

Researchers and authors have recourse to a special service which enables access to the top rated articles in any specified field of interest. The service is offered as a free privilege, is based in Charlottesville, USA and is aptly named: “Who is publishing in my domain?”

In 2012 Prof Vinesh Bookhan and Prof Francois de Wet published a paper in the South African Dental Journal. That paper has ever since held the top placing amongst all others in their domain. All other papers in the top twenty are international. An achievement and well deserving of an accolade… and an appreciation, for this place our JOURNAL in a prominent position. As Vinesh Bookhan observes, it is quality that counts! Well done indeed.

The top paper:
A comparative study of student vs supervisor diagnoses of anatomical abnormalities affecting the TMJ.
Bookhan V, De Wet FA. SADJ; 2012 Feb;67(1):8, 10-2.

MANDELA DAY is recognised internationally as 18TH JULY, a day on which everybody is asked to devote 67 MINUTES of their time towards making the world a better place.

By the time you read this, July 18th will have come and gone… but the sentiment, the intention, the philosophy will live on… and perhaps there may be an inspiration for us to continue to devote time “towards making the world a better place” with our everyday actions and interactions.

It is in our hands to make a difference.
In the late sixties, Professor Fred Hossack undertook a Dental Odyssey, travelling to the four corners of Dentistry Southern Africa and including a visit to the then Rhodesia. The motivation for this momentous journey was in pursuit of a dream, a vision that the Association could become a major player in the development of the profession. Even at that stage, Professor Hossack was known as The Grand Old Man of Dentistry… he continued to practice as a prosthodontist right into his late seventies. How well he deserved that appellation, that accord. His was the inspiration for an enterprise which has become a beacon in the achievements and activities of the Association.

On his visits to the Branches he presented his concepts, his dream that the profession could be a catalyst in the stimulation of researchers young and mature, who could make contributions to the advancement of our discipline. There were established at that time two funds… the Dentistry Development Fund and the Research, Education and Development Fund, fondly known as the RED fund. That Professor Hossack and his team were nobly successful is borne out most eloquently by the Honours Boards housed (but not currently displayed) at the Head Office of the Association. Since inception of the funds, there have been numerous awards each year.

The Dentistry Development Fund and the RED Fund grew and expanded. Successive Boards of Trustees, together with professional advisors, have managed the funds with exemplary care, enabling the continued support of research and travel for the benefit of the profession. Those receiving awards are required to present a detailed report on the conclusion of their project together with a paper submitted to the Journal for consideration for publication. The Funds were later consolidated into one entity, the Dentistry Development Foundation of South Africa, the first trustees being Len Becker, Fred Hossack, Gerald Knoetze, Mervyn Shear, Ken Titlestad and Roux Wentzel. So the Grand Old Man of Dentistry maintained an active role in the enterprise throughout.

Applications are required in considerable detail, enabling the Board to make rational and considered decisions and awards are made to a generous level. A formula is applied in the case of Travel Grants, which is related to the distances involved in the journeys. As with Research grants, recipients of the Travel Grants are required to submit a report, in this instance to the Trustees.

The objectives of the Foundation are succinctly described in the Trust Deed: to assist financially or otherwise through the provision of grants in the holding of congresses, conferences, lectures, meetings, symposia, public education programmes, seminars for the study, definition or improvement of dental practices or such other activity in the field of dental, natural or applied science for the extension of knowledge. The objectives have expanded considerably over the intervening years since Fred Hossack undertook his stimulating journey! In 2014, the Trust awarded grants to an amount close to one million rand. The Trust Fund is independent of the Association but it is the Association and its members who are justly proud to know that through their efforts in supporting the establishment of and in contributing to the Fund, significant strides in developing Dentistry have been made possible.

There are always obverse and converse sides to all enterprises. Let’s flip over and consider a radically different Fund… the Benevolent Fund. The Association has for many years managed a Fund whose objectives are quite simple… but most laudatory.… namely to offer some support to colleagues whose fortunes have foundered, whose health is faltering, who face an uncertain future. There are a small number of dentists amongst our community who receive each month a small grant through the Benevolent Fund. Unlike the DDFT which has some safety in resources, the Benevolent Fund continues to rely on contributions from members. And the time is rapidly approaching when the monies will dry up. So the contrast may be drawn… the Association is markedly successful in stimulating our younger members to conduct research, to travel to congresses, to attend Branch meetings…but we are not so conscious, nor so conscientious, about looking after less fortunate older colleagues who have made their contributions to Dentistry South Africa over so many years.

This Communique places an appeal to all members to support the Benevolent Fund… let the memory of Fred Hossack invoke a commitment to ensure that the Association may continue its work as a supporter not only of research but also of colleagues who can no longer rely on their professional prowess to survive. They remain an integral part of the dental community.

Donors should contact the CEO, Maretha Smit in the first place but should also be alert to the PLEDGE button which will be available on our new website, scheduled for August. Every appreciation.
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References:
11. Touchstone research February 2014.

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Recent perspectives vis-à-vis the biological basis of tooth eruption

SADJ July 2015, Vol 70 no 6 p238 - p241
S Nel¹, HD Hendrik², SC Boy³, EJ Raubenheimer⁴

ABSTRACT
A thorough understanding of recent advancements regarding the molecular interactions responsible for tooth eruption is indispensable to all dental specialties and may provide insight for treating clinical eruption disorders. The biological processes responsible for tooth eruption have long been a matter of debate. Several types of cells of dental origin and numerous molecular factors that were believed to be responsible for this process have repeatedly been considered and investigated. Most existing eruption theories have concentrated on selective cells or processes as the sole generating forces of tooth eruption. This article reviews previously proposed eruption theories, in the light of significant advances in the understanding that the sequential interactions between dental epithelium and ectomesenchymal cells pattern the initiating cascade of the eruption process. These findings are presented in the context of tooth development within the milieu of a changing bony socket. Understanding the process of tooth eruption in this framework points to the fact that tooth eruption is essentially a stage of tooth development which, through selective resorption and deposition of bone, allows the developing tooth to be displaced through the alveolar bone to its position of function in the oral cavity.

Key words: tooth eruption, dental follicle, paracrine signaling, bone remodeling

INTRODUCTION
Tooth movements during the lifetime of an individual can generally be divided into pre-eruptive, eruptive and post-eruptive phases. For the purpose of this overview we will focus on the eruptive phase only. Tooth movements during this phase are subdivided into intra-osseous and supra-osseous stages referring to the movement of the tooth from a position within the bone to its functional position in occlusion. Tooth eruption is a complex process in which the interplay of several tissues and mechanisms have been proposed. All the tissues within the vicinity of the tooth, and thought to be capable of generating some kind of force, have been implicated as contributing to the process of tooth eruption. Common theories of dental eruption include hydrostatic pressure, the periodontal ligament, root formation and elongation, selective bone resorption and formation, and the role of the dental follicle surrounding the developing tooth.

The purpose of this article is to review the previously proposed mechanisms of tooth eruption as a platform for presenting the newest significant findings regarding the intricate interplay of inductive signals between the dental follicle, reduced enamel epithelium, stellate reticulum and alveolar bone in the process of tooth eruption.

HISTORICAL THEORIES
The hydrostatic pressure theory is one of the oldest tooth eruption theories known.⁵ According to this theory, blood pressure exerted in the vascular tissue between a developing tooth and its bony surroundings creates a mechanical force causing tooth eruption.⁶ Although a pressure gradient from apical to occlusal was revealed in the teeth of dogs, this theory was contradicted by studies which proved hypertensive drugs⁷ and hemodynamic influences such as changes in pulse rate and blood pressure⁸ to not have any effect on tooth eruption. Other studies on human and rat

ACRONYMS
BMP-2: Bone Morphogenetic Protein-2
CSF-1: Colony-stimulating Factor-1
DF: Dental Follicle
EGF: Epidermal Growth Factor
ERS: Epithelial Root Sheath
IL-1α: Interleukin-1α
MCP-1: Monocyte Chemotactic Protein-1
MMPs: Matrixmetallopeptidases
RANKL: Receptor Activator of Nuclear factor Kappa B Ligand
REE: Reduced Enamel Epithelium
TNF-α: Tumour Necrosis Factor-α
teeth respectively propose contradictory mechanisms and therefore this theory remains inconclusive.

Fibroblasts and collagen fibers of the periodontal ligament have long been implicated as generating the eruptive force for tooth eruption. The proliferation and subsequent occlusal migration of these periodontal ligament fibroblasts have been proposed as main factors responsible for tooth eruption. Periodontal fibroblasts in an in vivo situation of eruption exhibit characteristics of cells actively synthesizing and secreting protein rather than those of motile or contractile cells as described by these studies. The role of collagen has also been investigated, but the use of sodium morrhuate, known to reduce production and maturation of collagen, had no effect on the process of eruption. Collagen remodeling has been proposed to be a crucial factor in tooth eruption and the lack of matrix metalloproteinases (MMPs) seems to be related to abnormal tooth eruption in humans. Collagen, its synthesis, remodeling and the cells implicated in these processes can however not be accepted as the sole mediators of tooth eruption as a tooth without a periodontal ligament can still erupt. It is however possible that the periodontal ligament could play a role in the supra-ossseous phase of the eruptive process in lifting the tooth into the occlusal plane.

The theory that root formation results in tooth eruption seems plausible as both processes take place simultaneously. It seems logical that root formation and subsequent elongation would result in extrusion of the tooth from the bony socket. It has however been proven by studies in dogs and mice that rootless teeth do erupt and that teeth may also sometimes erupt a greater distance than the length of the roots. Pressure applied to bone generally results in bone resorption. Therefore, if root elongation was indeed responsible for “pushing” the tooth into occlusion as the root elongates, it would mean that pressure would have to be applied to the bone by the elongating root. The force generated by this kind of pressure would definitely result in bone resorption at the apical base. Therefore root formation is accommodated during tooth eruption and can be regarded as a consequence, rather than a cause, of the process.

The dental follicle (DF) refers to the condensed ectomesenchyme encapsulating the unerupted, developing tooth. It was demonstrated, as early as 1980, that once the DF of unerupted teeth were surgically removed, those teeth failed to erupt. When a developing unerupted premolar tooth was surgically removed and replaced with a metal replica, the replica erupted, provided that the DF was retained. These studies clearly demonstrate the essential role of the DF in the process of tooth eruption, while simultaneously eliminating the role of other tissues such as the dental pulp, periodontal ligament and root formation.

Regional differences in the DF were described following further studies on dog premolars. If the basal (apical) half of the DF was left intact and the coronal half was removed, alveolar bone resorption did not occur, an eruption path did not form and the tooth eruption was impeded. Conversely, if the coronal half was left intact and the basal half removed, bone resorption did occur at the coronal aspect, but the tooth did not erupt as no bone was formed at the base of the tooth socket. Therefore this study suggested that the coronal aspect of the DF regulates osteoclastogenesis (bone resorption) and the basal aspect of the DF is responsible for osteogenesis (bone formation); both processes essential for tooth eruption. Regional differences in gene expression of the DF were assessed using laser capture microdissection. The coronal and basal halves of the DFs of rat first mandibular molars were isolated and RNA extracted from both halves respectively. Real time reverse transcription-polymerase chain reaction (RT-PCR) was used to measure the expression of marker genes for bone resorption (osteoclastogenesis) and bone formation (osteogenesis). The receptor activator of nuclear factor kappa B ligand (RANKL) gene was utilised as a marker gene for osteoclastogenesis, therefore for bone resorption. Bone morphogenetic protein-2 (BMP-2) gene served as a marker for osteogenesis or bone formation. The results showed a higher expression of bone-resorption genes (RANKL) in the coronal half of the DF, but higher expression of bone-formation genes (BMP-2) in the basal half of the follicle. Therefore, clearly, the DF regulates bone formation and resorption via spatial expression of different genes at different levels and times.
Current concepts regarding the paracrine signaling role of the dental follicle in tooth eruption

Tooth development is initiated and crown and root development regulated by a cascade of reciprocal interactions between the dental epithelium and the dental mesenchyme. Correspondingly, the process of tooth eruption is represented by a cascade of cellular events leading to the recruitment of monocytes to the dental follicle followed by osteoclastogenesis and bone resorption, a prerequisite for tooth eruption. This cascade of molecular events is initiated by epithelial-ectomesenchymal interactions between the dental follicle, the reduced enamel epithelium (REE) and the stellate reticulum (Figure 2). The REE consists of the layer of ameloblasts fused with the stratum intermedium, stellate reticulum and the outer enamel epithelium upon completion of crown formation. Apoptosis of epithelial cells of the stellate reticulum, stratum intermedium and ameloblast layer during the advanced stages of enamel secretion have been reported. This apoptotic process is believed to have a direct influence on osteoclastogenesis through the release of interleukin-1α (IL-1α) by the cells of the stellate reticulum, the receptors for which are located on the cells of the dental follicle. IL-1α subsequently stimulates the expression of colony-stimulating factor-1 (CSF-1) and monocyte chemotactic protein-1 (MCP-1) within the cells of the dental follicle, thereby allowing the dental follicle to act as a chemoattractant for monocytes. Additionally, the REE also secretes proteases that aid in creating an eruption pathway for the tooth through enzymatic digestion of collagens. Other molecules such as epidermal growth factor (EGF) and transforming growth factor β 1 (TGF-β1) released by the cells of the dental follicle further enhance the expression of CSF-1 within the dental follicle. Paracrine signalling involving both the ectomesenchyme derived dental follicle and epithelial cells of the REE and stellate reticulum are therefore key role players in the process of tooth eruption. In the study, conducted in 1984, where tooth crowns were removed and replaced with metal or silicone replicas which “erupted” into the oral cavities, the authors did not specifically mention whether the REE of the 15 week old beagle dogs was retained or removed with the tooth crowns during the study. If we assume that the REE was removed during the procedure, we propose that the dental follicles associated with the metal replicas had already received signalling from the epithelial cells at the stage of surgical intervention. Signalling for monocyte attraction to the area of resorption had therefore already been accomplished at that stage, which apparently allowed eruption of the object.

Bone resorption with the creation of an eruption pathway is however not sufficient for the displacement of the tooth from its bony crypt into occlusion. Coronal bone resorption is therefore coupled with apical bone formation resulting in the physical displacement of the erupting tooth. The dental follicle cells located in the basal aspect express bone morphogenic proteins 2 and 3 (BMP 2 and BMP 3) responsible for the promotion of bone formation. The expression of these BMP’s is greatly enhanced by tumour necrosis factor–α (TNF-α) expression in the dental follicle cells. TNF-α expression is maximally upregulated in the rat dental follicle when rapid bone deposition occurs at the base of the tooth crypt. The cascade of signalling events associated with tooth eruption at the apical aspect of the developing tooth, have not been completely elucidated. Further studies are required to shed some light on the reciprocal signalling between the epithelial root sheath cells and the associated dental follicle during the eruptive process.

CONCLUSION

Tooth eruption represents a series of precisely regulated cascades of paracrine signaling events between epithelial cells of the enamel organ and ectomesenchymal cells of the dental follicle. These tightly regulated processes which bring about selective alveolar bone resorption in the coronal aspects of the erupting tooth and bone formation in the apical aspects of the tooth, are considered central to the process of tooth eruption.

The authors thus propose that tooth eruption should be regarded as a stage of tooth development which, through epithelial-ectomesenchymal interactions, represents the very mechanism that allows the dental follicle to assume its fundamental role in the process of selective bone remodeling required for the movement of a tooth from its developmental position in bone to its functional position in the oral cavity.

References


Assessment of dose-width products of pre-programmed exposure technique parameters in panoramic dental radiology: a comparison of methodologies

ABSTRACT

The dose width product (DWP) at the receiving slit of a panoramic dental unit is indicative of the radiation dose a patient receives in a panoramic dental examination. It is a useful tool for assessing the pre-programmed exposure technique settings of a dental unit. Panoramic units are equipped with these parameters, but the radiation doses delivered to patients when these programs are activated are not well defined. This study assesses DWPs of pre-programmed exposure technique parameters at the receiving slit of a panoramic unit, using Gafchromic XRQA2 film which progressively darkens when exposed to radiation, and a pencil ionization chamber, which gives a direct readout of the DWP when an exposure is initiated. The exposed film is scanned into a desktop computer and the extent of colour change analysed with a free Java image processing program. The maximum percentage difference between the two methods for DWP estimation was less than 13%, consequently, Gafchromic XRQA2 film is regarded as suitable for DWP assessment in panoramic dental procedures. Although the DWPs of some of these exposure technique charts exceeded the recommended diagnostic reference level (DRL) of 65mGym; they were similar to published data from other researchers.

ACRONYMS

ALARA: as low as reasonable achievable
DRL: diagnostic reference level
DWP: dose width product
IPEM: Institute of Physics and Engineering in Medicine
NRPB: National Radiological Protection Board

Key words: Panoramic dental unit, exposure techniques, Gafchromic XRQA2 film, diagnostic reference level, radiation doses

INTRODUCTION

Panoramic dental digital radiography exposes all the teeth and neighbouring structures of a patient to produce a single digital image. These units are equipped with preprogrammed exposure technique parameters for different patient sizes, to improve work flow and to reduce the need for repeat digital radiographs which would expose patients to unnecessary radiation. The total radiation quantity delivered to patients in panoramic dental examinations partially depends upon the exposure parameters which can be selected manually or derived from a pre-programmed set. Exposure parameters should deliver digital images with adequate diagnostic image quality while keeping radiation doses absorbed by patients as low as reasonable achievable (ALARA principle).

Napier¹ has recommended the dose width product (DWP) as the dose metric indicative of the total quantity of radiation delivered to patients during standard adult panoramic procedures. It is defined as the product of the absorbed dose in air over an exposure cycle and the horizontal width of the beam, both measured at the receiving slit of the panoramic dental unit. This is easy to ascertain and does not require the presence of a patient during assessment. It is therefore a reliable reference for limiting the dose and optimising image quality in any panoramic procedure. The National Radiological Protection Board (NRPB), in "Guidance notes for Dental Practitioners on the Safe Use of..."
X-ray Equipment2 and the Institute of Physics and Engineering in Medicine (IPEM) Report No. 889 recommend the DRL for DWPs as 65mGym for panoramic dental procedures. The DRL represents the third quartile value from the distribution of radiation delivered to patients for a particular procedure by a variety of X-ray machines - in this case panoramic dental units. It provides a means for clinicians and other interested parties to compare radiation exposures to patients from panoramic dental units by different manufacturers. In addition, it can serve as a tool to identify unusually high radiation exposures delivered to patients in standard panoramic procedures. The DWP does not take into consideration the height of the radiation beam. Different units may have slits of differing height which will affect the dimensions of the beam. Consequently, the IPEM Report No. 9110 has endorsed the dose area product (DAP) as the dose metric for DRL in panoramic dental examinations. It is defined as the product of DWP at the image receptor slit and the height of the radiation beam at the image receptor slit.10 Recently, many authors6,7,14 have utilised the DWP at the receiving slit in reporting DRLs in panoramic dental procedures and some have reported values exceeding the recommended DRL of the IPEM Report 88. In a dental practice with a single panoramic dental unit, DWP is still an appropriate dose metric to evaluate pre-programmed techniques, as the height of the radiation beam at the image receptor is constant for all exposures. However, exposure techniques with DWPs exceeding the recommended DRL should be investigated with the DAP metric.

Gafchromic XRQA2 film6 darkens when exposed to ionizing radiation, the film density being proportional to the quantity of radiation it receives. The film is self-processing and can be scanned with a standard flatbed document scanner.6 It is sensitive over a dose range of one to 200mGy for radiation beams of 20 – 200 peak kilo voltage (kVp), where kVp represents the radiation beam energy.

A computed tomography (CT) pencil ionization probe, (Victoreen Model 500-200, high sensitivity 10cc CT ion chamber) consists of a chamber with a sensitive length of 100mm. It measures the integral dose delivered in an exposure cycle and provides a direct readout value of the DWP for a given set of exposure parameters.

AIM

This study assesses and compares the DWPs of pre-programmed exposure techniques of a panoramic dental unit (Planmeca Proline XC) using Gafchromic XRQA2 film and a CT pencil ionization chamber as assessment methods. The DWPs are also compared with the recommended DRL of the IPEM report 88 and with published data from other researchers.6,7,14

MATERIALS AND METHODS

Measurement of dose width products with a CT ionization chamber

A CT pencil chamber is calibrated in a secondary standard dosimetry laboratory, by exposing the entire length of the chamber in a known uniform radiation field. When a CT probe is placed perpendicular to the receiving slit of the secondary collimator, a partial volume of the probe is irradiated and charges are collected along the entire length of the probe. The DWP is estimated in accordance with a standard formula and is provided as a direct read out value.

With the standard 100mm long pencil probe, the CT dose index (CTDI) is a CT dose descriptor which represents the integrated dose along a dose profile \(D(z)\) over the length of a pencil chamber and it is expressed as:

\[
\text{CTDI}_{100} = f \int_{-50\text{mm}}^{+50\text{mm}} D(z) \, dz = \frac{f \cdot E \cdot \text{TP} \cdot L}{T}
\]

where \(f\) is the conversion factor from exposure (mR) to dose in mGy, \(E\) is the measured exposure, \(\text{TP}\) is the temperature and pressure correction factor, \(T\) is the nominal slice thickness and \(L\) is the length of the probe. The DWP is estimated according to this formula:

\[
\text{DWP} = f \cdot E \cdot \text{TP} \cdot L
\]

A piece of film is placed on the receiving slit of the secondary collimator. An exposure is initiated to identify the centre of the slit. The CT probe is placed perpendicular to the slit, such that the centre of the CT probe is co-incident with the centre of the slit as shown in Figure 1. For each set of pre-programmed exposure technique parameters an exposure is activated and the value for the DWP is noted. It is repeated three times and the average is recorded as the DWP for that set of exposure parameters. This is repeated for all available pre-programmed exposure technique parameters for an average sized adult.

Figure 1: CT pencil ionisation chamber across the width of the receiving slit of the secondary collimator.

Measurement of dose width products with Gafchromic XRQA2 film

Sheets of Gafchromic® XRQA2 film (International Specialty Products Lot#: A10121202 and dimensions 10" x 12") are cut in rectangular pieces with dimensions 8.8cm x 1.8cm.

The CT pencil chamber is replaced with a piece of film as shown in Figure 2. The length of the film covers the entire height of the slit. An exposure is initiated with one of a set of pre-programmed exposure technique parameters and the film is placed in a marked envelope. The exposure parameters are noted. This is repeated three times with different pieces of film. The process is repeated for all available pre-programmed exposure technique parameters for an average sized adult. The films are scanned into a desktop computer with a flatbed document scanner 24 hours later while implementing the recommendation stated in Delic et al.10 The image of each piece of film is analysed with ImageJ which is a free Java image processing program on the Internet.11,12 It converts the net optical density of the film to pixel values.
The calibration equation for the conversion of film optical density to dose for this batch of films has previously been determined with an in-house method. This method utilises an ionization chamber whose calibration factor has been determined in a secondary standard laboratory and an X-ray unit whose performance is in compliance with the recommended tests from the Department of Health - Radiation Control, South Africa. The calibration equation is given as:

\[
\text{Dose (mGy)} = \frac{(34.693 \times \text{NOD})}{(0.336 - \text{NOD})}
\]

where NOD is the net optical density of the film. The estimated error associated with the in-house calibration curve was less than 10% (Gy is a unit of radiation known as Gray and represents one joule of energy absorbed by one kg of tissue, 1 mGy = 0.001 Gy).

**DATA ANALYSIS**

**Conversion of pixel values to Net Optical Density**

When a radiation beam is incident on a Gafchromic XRQA2 film, the film darkens. The optical density is a measure of the amount of film darkening and is therefore a measure of the total radiation incident on the film. Unexposed films have inherent background optical density for which a correction factor must be determined, and the NOD is then expressed as a function of the pixel values, a measure of the light intensity. These calculations are made in accordance with a standard formula.

The Net Optical Density (NOD) corrects for the background optical density and it is expressed as:

\[
\text{NOD} = \log \left( \frac{l_u}{l_t} \right) - \log \left( \frac{l_u}{l_0} \right) = \log \left( \frac{l_0}{l_t} \right)
\]

where \(l_i\) is the intensity of the light transmitted through or reflected from the exposed film and \(l_0\) is the intensity of the light transmitted through or reflected from an unexposed film and \(l_u\) is a reference light intensity incident on the film. In ImageJ, the NOD is expressed as a function of the pixel values, where, a pixel value is a measure of the light intensity. Consequently, the above equation can be written as:

\[
\text{NOD} = \log \left( \frac{\text{PV}_{\text{before}}}{\text{PV}_{\text{after}}} \right)
\]

with \(\text{PV}_{\text{before}}\) = average pixel values of a given region of interest from an unexposed film and \(\text{PV}_{\text{after}}\) = average pixel values of a given region of interest, of the same size as that of the unexposed film.

Determination of the full width at half maximum (FWHM) of the NOD profile across the width of the slit as shown on the scanned image.

The NOD values obviously vary across the width of the film, the peak values being in the region where the film was superimposed over the columella slit. In order to produce a single value which represents the distribution, a calculation is undertaken. Consider first the image depicted in Figure 3a, which shows the darkened vertical rectangle of greatest exposure. A horizontal line is drawn across the image (Figure 3b) and the NOD values are recorded across the width of the image. Their distribution is shown in Figure 4 as a plot on a graph. Clearly the maximum occurs right over the position of the collimator slit. The graph is not a Gaussian curve and the single NOD reference value was therefore calculated as representing half of the maximum NOD value of the profile. The width at points where the NOD value is equal to this reference value is known as the “full width at half maximum (FWHM)” of the NOD values.

Isoardi et al. [14] utilised measurements from thermoluminescent dosimeters (TLDs) to compute the mean dose along the line profile across the width of the slit. They considered only values greater than the baseline value for absorbed dose determination. They also defined the average value of these TLD readings as the mean dose imparted to the slit. The DWP was calculated as the product of the mean dose and the FWHM. This study utilises the same approach, where the mean NOD, which is representative of the radiation dose imparted to the film, is calculated as the mean of the NOD values above the baseline value sampled at 1mm along the x-axis. The mean NOD is converted to radiation dose (Dm) and the DWP is defined as the product of Dm and FWHM.

**RESULTS AND DISCUSSIONS**

The pre-programmed exposure technique parameters for an average sized adult are shown in Table 1. The DWP of the pre-programmed exposure technique parameters are
shown in Table 2, which includes data from both techniques. The greatest difference in measurement between the two methods is less than 13%. Figure 5 shows a plot of DWP measurements from the CT pencil chamber and from the Gafchromic XRQA2 film process for pre-programmed exposure parameters. The 45° trend line indicates a good correlation between the two methods (correlation coefficient >0.98). Hence Gafchromic XRQA2 film can be used for DWP measurements of pre-programmed exposure technique parameters of panoramic dental units. Moreover, the films are affordable and easy to use. The DWPFs from the unit investigated in this study compare well with published data (Table 3). Walker C et al.6 reported a DRL of 59.89 ±20.97mGymm for adult panoramic radiographs in Irish dental practices while Lee JS et al.7 have cited the highest DWP in their study as 148.9mGymm. The mean DWP of the current study was 91± 37.8mGymm, measured with the CT probe. The authors were informed that the exposure parameters of MODE 4 and 5 were rarely used for patient studies, nevertheless they recommended that pre-programmed exposure techniques with DWPFs greater than 65mGymm should be investigated with the dose area product metric.

### CONCLUSION AND RECOMMENDATIONS

This study shows that pre-programmed exposure technique parameters of panoramic dental units should be investigated, and where necessary, dose and image quality optimisation processes should be implemented to ensure that the ALARA principle is upheld. The authors are committed to assess the DAPs of all future exposure parameters. Gafchromic XRQA2 film provides an inexpensive methodology for assessing these dose metrics which are necessary for optimisation of radiation protection in panoramic dental radiology. Moreover, it is highly probable that in the near future, these dose metrics will be required by the Department of Health-Radiation Control, South Africa for the licensing of all panoramic dental units.15

### Acknowledgement

We wish to thank the Head of Clinical Imaging Services, Dr FA Gebremariam of Pelonomi Hospital, for granting us access to the Panorex Dental Unit at Pelonomi Hospital, Bloemfontein.

### References

Building a new layer of protection.

Sensodyne® Repair & Protect harnesses advanced NovoMin™ technology to help build a robust hydroxyapatite-like layer over exposed dentine and within dentine tubules. With Sensodyne® Repair & Protect, you can do more than help relieve the discomfort of dentine hypersensitivity – you can help repair and protect your patients’ exposed dentine.
Building on technology

Originally developed for bone regeneration, NovaMin™ delivers calcium and phosphate into your patient’s enamel and dentine and provides favourable conditions for hydroxyapatite-like layer formation.

Building a reparative layer

From as quickly as the first use, in vitro studies have shown a hydroxyapatite-like layer forming over exposed dentine and within the dentine tubules that is 50% harder than dentine.

![Pre-brushing](image1)
![Post-brushing](image2)
![Post-acidic challenge](image3)

In vitro SEM images of the tooth surface pre-brushing, of a reparative layer formed after twice-daily brushing for 4 days and of a reparative layer post a 5-minute acidic challenge.

Building an integrated and resilient layer

The hydroxyapatite-like layer formed binds firmly to the collagen in the patient’s dentine and helps protect your patients from the chemical and physical oral challenges they encounter in their everyday lives.

In vitro studies have shown that the robust layer builds up over 5 days and, with twice-daily brushing, provides patients with continual protection from dentine hypersensitivity.

References:

GlaxoSmithKline South Africa (Pty) Ltd, 57 Sloane Street, Bryanston 2021. Consumer Care Line: Tel: 0800 118 274, E-mail: consumer.careline@gsk.com. For full prescribing information see package insert. For product safety issues, please contact GSK on +27 (0)11 745 6001.
The effect of pre-etching of dentine, cut and uncut enamel on the shear bond strength of silorane-based and methacrylate-based composite resin systems

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SUMMARY

Introduction: Modern composites are exceptional physically and aesthetically, but success is dependent on effective bonding to tooth structures, possibly enhanced by phosphoric acid pre-etching.

Aims: To determine the effect pre-etching of tooth surfaces has on the shear bond strengths of silorane-based and of methacrylate-based composite resin systems.

Method: To 120 recently extracted human molars and pre-molars, composite resin stubs were bonded with Silorane System Adhesive or Scotchbond Universal, to pre-etched or to non-pre-etched tooth surfaces, using an Ultradent jig. After thermocycling, each specimen was debonded under a shear force, in an Instron Universal testing machine (crosshead speed 0.5mm/minute).

Results: Data were subjected to an analysis of variance and when significant, to pairwise comparisons. The silorane-based system achieved significantly higher mean shear bond strengths (MPa) on pre-etched surfaces of: uncut enamel (15.204 vs 9.424), cut enamel (21.352 vs 12.110) and dentine (19.787 vs 8.278). Methacrylate-based bonds to pre-etched uncut enamel were significantly stronger (28.898 vs 18.451). Pre-etching cut enamel enhanced the bond (20.548 vs 16.384, not significant). Pre-etched dentine recorded lower mean bond strengths (15.288 vs 19.645) also not significantly.

Conclusions: The effect of pre-etching on the shear bond strength to uncut enamel, cut enamel, and dentine was product-specific.

INTRODUCTION

The increasing popularity of dental composites as restorative materials on posterior teeth has forced manufacturers to contend in the on-going ‘Battle of the Bonds’, in order to remain competitive in the constantly advancing and innovative world of dental materials. The introduction of the sixth and seventh generation bonding agents in the late 1990’s enabled the dental fraternity to finally eliminate the problems of technique, and of post-operative sensitivity. These “self-etching adhesives” have further contributed to the increasing popularity of dental composites.

The major disadvantage with composites has always been polymerisation shrinkage and its associated polymerisation stress. Volumetric shrinkage, in the range of <1% up to 6%, has been reported for filled dimethacrylate-based dental composites.1 This polymerisation shrinkage results in an associated polymerisation stress on the tooth-resin interface which may lead to: microleakage, marginal staining, tooth deformation, enamel cracks, stress-induced post-operative sensitivity and eventually failure of the restoration.2 This is more pronounced in high ‘C-factor’ cavities. The ‘C-factor’ is defined as the ratio of bonded to unbonded areas within a restored cavity.1,4 The higher the C-factor, the lower the potential for plastic deformation and relaxation of the composite resin (i.e. the less likely a restoration can withstand shrinkage).1,5 In 2007 3M ESPE introduced Filtek Silorane, the first direct posterior composite displaying < 1% polymerisation shrinkage.2 Even though reduced polymerisation shrinkage has been

ACRONYMS

FS: Filtek Silorane
FSX: Filtek Supreme XTE
HEMA: 2-hydroxyethyl methacrylate
SBS: shear bond strength
SEP: self-etching primer
SSA: Silorane System Adhesive
SUA: Scotchbond Universal Adhesive

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achieved with this silorane-based composite, it comes at the cost of convenience. Since the curing of this resin system involves chemical mechanisms different from those of conventional methacrylate-based composites, a dedicated adhesive is needed to bond to the silorane-based composite. Incremental layering of the composite material has always been and is still recommended as one of the main techniques useful in minimising the effect of polymerisation shrinkage in high C-factor cavities. Other clinical techniques include: modifying cavity configurations; directional curing techniques; variations in curing modes (such as “Soft Start”, “Ramped curing” and “Delayed curing”) as well as the use of stress breaking liners.

Contemporary dental composites display exceptional mechanical properties, low polymerisation shrinkage and pleasing aesthetics, but the success of the material is ultimately dependent on its ability to bond to tooth structure. The question then arises: “What is a clinically acceptable bond strength?” An answer to this question was hypothesised by Munksgaard in 1985 and Retief in 1994. They proposed that a minimum bond strength of 17 MPa to tooth structure was required for successful adhesion. If the bond strength to tooth structure is less than 17 MPa, it means that the polymerisation shrinkage of the composite resin is greater than the force adhering the material to the tooth. Therefore, polymerisation shrinkage causes the resin to contract toward the centre of the composite, thus pulling the restorative material away from the walls of the cavity. This leads to marginal gap formation which then allows the micro-infiltration of bacteria which will eventually lead to marginal breakdown and composite failure.

When bond strengths to tooth structure exceed 17 MPa, the shrinkage of the composite is toward the walls of the cavity. The laws of entropy dictate that the polymerisation contraction process always tends to go in the direction of least resistance (or higher attraction) and since the composite is more attracted to the tooth surfaces than it is to itself, shrinkage occurs toward the walls of the cavity and away from the centre, resulting in no marginal gap formation. Therefore, adhesive systems must have bond strengths greater than 17 MPa to be considered clinically acceptable. Bond strengths to enamel and dentine should also be relatively equal. If, for instance, the adhesion to enamel is much greater than the adhesion to dentine, during polymerisation the stronger force at the enamel interface will pull the composite away from the dentinal interface thus weakening it.

The idea of etching enamel in order to improve bonding of restorative materials, all began in 1955 when Dr Michael Buonocore published a paper titled “A simple method of increasing the adhesion of acrylic filling materials to enamel surfaces”. The acid etching of dentine on the other hand was initially frowned upon. In 1979 Fusayama and colleagues made a breakthrough, and published a study demonstrating that acid etching of dentine substantially improved adhesion of composite restorations, without the risk of pulpal damage. However, etching of dentine was only widely embraced in the early 1990’s.

The introduction of the self-etching sixth and seventh generation bonding systems in the 20th century, eliminated the need for the initial step of acid etching. The main concern with these bonding systems, however, is their mild acidity and short tooth application time resulting in insufficient etching of enamel. It is not surprising that to date many clinicians, opinion leaders and researchers still favour the “total etch” bonding systems.

The null hypotheses to be tested were as follows: 1) Pre-etching of dentine, cut and uncut enamel does not significantly affect the shear bond strengths of the silorane-based composite resin system. 2) Pre-etching of dentine, cut and uncut enamel does not significantly affect the shear bond strengths of the methacrylate-based composite resin system. Thus, the aim of this study was to determine the effect that pre-etching of dentine, cut and uncut enamel would have on the shear bond strengths of both a silorane-based and a methacrylate-based composite resin system.

MATERIALS AND METHODS

The Silorane System Adhesive (SSA) (Lot number: N322114) and its paired low shrinkage posterior restorative composite Filtek Silorane (FS) (Lot number: N344850) manufactured by 3M ESPE (Seefeld, Germany), was one of the systems chosen for this study. SSA is classified as a two-step, mild, sixth generation type I self-etching bonding system. It is a two bottle system, a self-etching primer (SEP) with a pH of about 2.7 and an adhesive bond. The acidic monomer used in the SEP is an unidentified phosphorylated methacrylate. SEP also contains a “Vitrebond copolymer” with carboxylic acid functionality. Other components include: bisphenol A diglycidyl methacrylate (Bis-GMA); 2-hydroxyethyl methacrylate (HEMA); 1,6-hexanediol dimethacrylate (HDDMA); silane-treated silica filler particles and a camphorquinone-based photo-initiator. This SEP uses both water and ethanol as solvents. The functionality of Silorane Adhesive is based on methacrylate chemistry, for it contains as a main component a hydrophobic bifunctional monomer that allows for easy adaptation of Filtek Silorane composite on the cured adhesive layer.

The methacrylate-based bonding agent Scotchbond Universal Adhesive (SUA) (Lot number: 455901) together with the nanocomposite Filtek Supreme XTE (FSX) (Lot number: N340262) (3M ESPE, Seefeld, Germany), was one of the systems selected for this study. SUA is classified as a mild seventh generation self-etching bonding agent, with a pH of about 2.7. It is a single solution system containing methacryloyloxydicyl dihydrogenphosphate (MDP); dimethacrylate resins; HEMA; a “Vitrebond copolymer”; filler particles; initiators and silane in an ethanol/water based solvent. The paradox surrounding Scotchbond Universal, however, is that it can be used in ‘self-etch’, as well as in ‘total etch’ and ‘selective etch’ modes. This means that the operator can choose to pre-etch all, or selected, tooth structures with 34 % phosphoric acid before application of this single solution adhesive system.

In this in vitro study, 120 caries-free posterior teeth were collected from Medunsa Oral Health Centre exodontia clinic and other surrounding clinics in the northern parts of Pretoria. The sample size was determined from similar previous studies. All teeth were stored in a 0.5 % solution of Chloramine T trihydrate (Merck Group, Darmstadt, Germany) during the collection period. The teeth were first cleaned, ensuring removal of any residual periodontal tissue and calculus, and mounted in Bencor stainless steel rings (Danville Engineering, San Ramon, CA, USA), using Excel self-curing acrylic (Wright Health Group, Kingsway,
West Dundee, Scotland. The teeth were mounted with the bonding surfaces parallel to the base of the ring to ensure a force application perpendicular to the long axis of the resin stub.

Eighty teeth were randomly selected, de-rooted and mounted with their buccal or lingual surfaces facing upwards. Forty of the eighty teeth were ground to a flat surface, removing about 0.5 mm of the superficial layer of enamel on the buccal/lingual surfaces, using an Implant grinder (Innovative Met Products, Boksburg, South Africa) fitted with P600 grit SiC sandpaper under water cooling. The ground enamel surface was used as the bonding site for cut enamel. The other 40 teeth were used for bonding to uncut enamel. The remaining 40 of the 120 teeth were mounted with their occlusal surfaces facing upwards, and the middle dentine was exposed by removing approximately 1/3 of the crown using the Implant grinder fitted with P600 grit SiC sandpaper under water cooling, providing suitable bonding sites. Before bonding of the composite resins was carried out, all specimens were stored in distilled water in a Memmert Laboratory oven (Memmert, Schwabach, Germany) at 37°C for at least 24 hours.

An Ultradent mould (Ultradent, Salt Lake City, UT, U.S.A.) with a central opening of 2.3798 mm in diameter and 3 mm in length, was used in conjunction with the Ultradent bonding jig (Ultradent, Salt Lake City, UT, U.S.A.) when bonding the composite resin stubs to the selected bonding surfaces. Bonding to pre-etched and non-pre-etched tooth substrates was performed strictly according to manufacturer’s instructions.

When the SSA and FS combination was utilized for bonding to substrates that were not pre-etched, each specimen was first cleaned using an aqueous slurry of fine pumice powder, gently rinsed and dried with oil-free, dried, compressed air. This was followed by the application of the SSA-Self-Etching Primer for approximately 15 seconds. This primer was then spread over the bonding surface using a gentle stream of air and thereafter light cured for 15 seconds. Each tooth specimen was then clamped in the Ultradent bonding jig, ensuring that the prepared surface of the tooth was perpendicular to the long axis of the central opening of the mould. The central opening of the mould was then sequentially packed with two equal increments of FS composite resin material and light cured for 40 seconds per increment, using the Mini LED curing light. The Ultradent jig was then loosened and removed from the bonded specimen by gently applying downward force on the mould. When bonding to pre-etched substrates, specimens were first cleaned with pumice, rinsed and dried as described earlier. Enamel and dentine surfaces were then etched with 34% phosphoric acid for 20 and 15 seconds respectively. The phosphoric acid was rinsed off and each specimen gently air dried with oil-free, dried, compressed air. The remaining steps for SUA application and resin stub bonding as described in the paragraph above were then followed.

When bonding SUA and FSX to pre-etched substrates, specimens were cleaned with pumice as described earlier, and enamel and dentine surfaces then etched with 34% phosphoric acid for 20 and 15 seconds respectively. The phosphoric acid was rinsed off and each specimen gently air dried with oil-free, dried, compressed air. The remaining steps for SUA application and resin stub bonding as described in the paragraph above were then followed. When bonding to pre-etched dentine using either system, caution was exercised not to desiccate dentine, but to only remove the excess water and to leave a glistening surface.

Immediately after thermocycling, each specimen was secured in an Ultradent ring clamp (Ultradent, Salt Lake City, UT, U.S.A.) and subjected to debonding under a shear force in an Instron Universal testing machine (Model 3366, Instron, Norwood, MA, U.S.A.). The resin stubs were debonded, using a notch shear castle attachment head at a crosshead speed of 0.5 mm/minute. The software package Bluehill version 2 (Instron, Norwood, MA, U.S.A.), loaded on a desktop personal computer with a Microsoft Windows XP (Microsoft Corp., Redmond, WA, U.S.A.) operating system, was connected to the Instron Universal testing machine in order to record the measurements. The maximum compressive load was recorded in Newtons and the maximum compressive stress at maximum compressive load was calculated in MPa.

De-bonded specimens were examined under a light microscope at 40x magnification and the mode of fracture recorded as: I = fracture occurred at the adhesive interface; C = cohesive fracture occurred within the composite resin and M = mixed fracture involving the tooth structure and adhesive junction occurred.

All data collected in the study were captured in a Microsoft Excel 2010 (Microsoft Corp., Redmond, WA, U.S.A.) spreadsheet. Data capturing was verified and validity checks were performed on the data. All statistical procedures were performed on SAS, Release 9.2 (SAS Institute, Inc., Cary, NC, USA), running under Microsoft Windows XP for a personal computer. Statistical tests were performed at a
significance level of 0.05. Normality was demonstrated for each of the groups, using the Shapiro-Wilk test. The mean shear bond strengths in MPa were compared by analysis of variance (ANOVA). The comparisons in the ANOVA included adhesive systems, tooth substrates and treatments. If the p-value of the ANOVA was significant, pairwise comparisons were done using the t-test (LSD) as part of ANOVA in SAS.

RESULTS

The shear bond strengths obtained when Silorane System Adhesive (SSA) and Filtek Silorane (FS) were used to bond to tooth substrates that were either pre-etched and pre-etched are presented in Table 1 and Figure 1. When uncut enamel was not pre-etched, a mean shear bond strength (SBS) of 15.20 MPa was recorded whilst pre-etching enhanced the SBS to a mean of 15.20 MPa, a significantly higher value (p=0.0151). Similarly, the SBS to pre-etched cut enamel is significantly higher than the bond to un-etched cut enamel (21.35 MPa vs 12.11 MPa: p=0.0001). When dentine was not pre-etched, a mean SBS of 8.28 MPa was recorded but pre-etching resulted in a significantly higher mean value of 19.79 MPa (p=0.0001).

When the bonds achieved with Scotchbond Universal Adhesive (SUA) and Filtek Supreme XTE (FSX) were tested, both uncut and cut enamel surfaces recorded higher shear bond strengths in MPa were compared by analysis of variance (ANOVA). The comparisons in the ANOVA included adhesive systems, tooth substrates and treatments. If the p-value of the ANOVA was significant, pairwise comparisons were done using the t-test (LSD) as part of ANOVA in SAS.

The mean shear bond strengths (MPa) obtained when Silorane System Adhesive (SSA) and Filtek Silorane (FS), bonded to tooth substrates that were either pre-etched or not pre-etched were not statistically significant (p=0.1085). Only one specimen bonded to pre-etched cut enamel showed a mixed fracture (i.e. involving both the tooth structure and the adhesive). When SSA and FS were used for bonding to pre-etched uncut enamel, an adhesive fracture rate of 100% occurred. When SSA and FS were used for bonding to pre-etched tooth substrates, an adhesive fracture rate of 96.6% occurred. Only one specimen bonded to pre-etched uncut enamel showed a mixed fracture. When SUA and FSX were used for bonding to pre-etched cut enamel, but not to a statistically significant difference (p=0.7108). On the other hand, SUA and FSX also performed better than SSA and FS when bonded to pre-etched cut enamel, although that difference was not statistically significant (p=0.0534). When bonded to dentine that was not pre-etched, SUA and FSX showed significantly higher mean SBS than SSA and FS when bonded to cut enamel that was not pre-etched, but this difference is not statistically significant (p=0.0534). When bonded to dentine that was not pre-etched, SUA and FSX showed significantly higher mean SBS than SSA and FS when bonded to dentine that was not pre-etched.

When SSA and FS were used for bonding to tooth substrates that were not pre-etched, an adhesive fracture rate of 100% occurred. When SSA and FS were used for bonding to pre-etched tooth substrates, an adhesive fracture rate of 96.6% occurred. Only one specimen bonded to pre-etched uncut enamel showed a mixed fracture (i.e. involving both the tooth structure and the adhesive). When SUA and FSX were used for bonding to tooth substrates that were not pre-etched, an adhesive fracture rate of 96.6% occurred. Again, only one specimen bonded to pre-etched uncut enamel showed a mixed fracture.

Thus, both the null hypotheses are rejected.

The mean shear bond strengths (MPa) achieved by both systems when bonded to tooth substrates without and with pre-etching are depicted in Figures 3 and 4. SUA and FSX showed significantly higher mean SBS than SSA and FS when bonded to uncut enamel that was not pre-etched (p=0.0003). SUA and FSX also showed a higher mean SBS than SSA and FS when bonded to cut enamel that was not pre-etched, but this difference is not statistically significant (p=0.0534). When bonded to dentine that was not pre-etched, SUA and FSX showed significantly higher mean SBS than SSA and FS when bonded to dentine that was not pre-etched.

When SSA and FS were used for bonding to tooth substrates that were not pre-etched, an adhesive fracture rate of 100% occurred. When SSA and FS were used for bonding to pre-etched tooth substrates, an adhesive fracture rate of 96.6% occurred. Only one specimen bonded to pre-etched uncut enamel showed a mixed fracture (i.e. involving both the tooth structure and the adhesive). When SUA and FSX were used for bonding to tooth substrates that were not pre-etched, an adhesive fracture rate of 96.6% occurred. Again, only one specimen bonded to pre-etched uncut enamel showed a mixed fracture.
with phosphoric acid prior to application of certain two-strength measurements when enamel was pre-etched studies have confirmed substantial increases in bond micro- and macro- resin-tag interlocking. 7,21,22,23 Several surface energy is also increased from 28mJ.m\(^{-2}\) to about logistically porous layer, 5μm to 50μm deep, is created; the approximately 10μm of the surface is removed, and a morpho - dentine zone with naked collagen fibres below the hybrid layer which would in turn jeopardize bond strengths.25,26,27

When enamel is etched with phosphoric acid, approximately 10μm of the surface is removed, and a morphological porous layer, 5μm to 50μm deep, is created; the surface energy is also increased from 28mJ.m\(^{-2}\) to about 42mJ.m\(^{-2}\) thus enhancing the potential for bonding via micro- and macro- resin-tag interlocking.21,22,23 Several studies have confirmed substantial increases in bond strength measurements when enamel was pre-etched with phosphoric acid prior to application of certain two-step self-etching adhesive systems.23-27

The significant improvement in SBS to pre-etched dentine by SSA recommend pre-etching of uncut enamel, but claim that pre-etching of cut enamel and dentine is unnecessary.2 This study found that pre-etching of all three tooth substrates (uncut and cut enamel for 20 seconds and dentine for 15 seconds) with 34 % phosphoric acid significantly improved SBS (Table 1). The increased SBS when bonding to both uncut and cut enamel may be expected as the 34 % phosphoric acid (pH about 0.1) has strong etching potential. The mildly acidic SSA self-etching primer (pH 2.7) was unable to match the more aggressive phosphoric acid etch on both the uncut and cut enamel in order to create comparable micromechanical retention.

Studies documenting the effect of pre-etching of tooth structures on shear bond strengths when using SSA and FS are scarce. A study in 2013 concluded that pre-etching of dentine with 37% phosphoric acid, when combined with a moist dentine surface and the use of primer agitation, improved the micro-tensile bond strengths of SSA.29 An earlier 2008 study had, however, determined that phosphoric acid pre-etching of dentine did not significantly improve the micro-tensile bond strengths when using SSA,29 In the same study it is worth mentioning that, none of the pre-etched specimens had spontaneously de-bonded, compared with nine out of 52 specimens that spontaneously de-bonded when the dentine was not pre-etched.29

As mentioned earlier, SUA can be used in ‘self-etch’ mode, as well as in ‘total etch’ and ‘selective etch’ modes. It is claimed that SUA performs well on cut enamel and dentine when used in self-etching mode.15 The manufacturers do, however, recommend the pre-etching of uncut enamel before the application of SUA.15 The results obtained when the SUA/FSX system was used are presented in Table 2. A marked improvement in the SBS to pre-etched cut enamel and to a lesser extent to pre-etched dentine with the use of a self-etching adhesive system was an expected finding, and is consistent with results published by other researchers.23, 30-34

Taking into account the abundance of information available, it would be reasonable to conclude that most self-etching adhesive systems (the mild SEA systems in particular) do not bond as effectively to enamel as their total-etch counterparts.23,24 The main reason for this is that mild SEA only superficially acid should have resulted in an un-infiltrated resin-sparse dentine zone with naked collagen fibres below the hybrid layer which would in turn jeopardize bond strengths.
demineralises enamel, resulting in a very thin micro-retentive pattern without formation of micro- and macro-resin tags.27 This ill-defined etching pattern and planar interface has been associated with poorer bond strengths.23,27 When enamel is etched with phosphoric acid, the potential for bonding via micro- and macro-resin tag interlocking is enhanced. Based on the scientific evidence available, the increase in SBS to pre-etched uncut and cut enamel was exp-ected and can be justified.

Pre-etching of dentine, however, resulted in a decrease in SBS for SUA. Even though the drop in SBS is not statistically significant, this finding was expected and is also in accordance with the findings of other researchers.25,27,30,36,35 The lower bond strengths to pre-etched dentine can be attributed to incomplete infiltration of the demineralised collagen network and subsequent poor adaptation of the bonding resin to the collagen fibrils, thus leading to the formation of a non-homogenous, low-quality, porous hybrid layer that is prone to nanoleakage.25,26,27,35

Another possibility is over-etching of dentine (pre-etching followed by application of the SEA) which may have resulted in removal of the residual hydroxyapatite from the collagen mesh, which in turn could compromise the potential for chemical adhesion.25 Lastly the collapse of unsupported collagen after phosphoric acid treatment and exposure to air could inhibit resin monomer penetration into the entire depth of demineralised dentine. This possibility is, however, unlikely as SUA contains water as a solvent which should be capable of rehydrating the desiccated collagen fibres.

In general, the mean SBS of SSA and FS bonded to tooth substrates that were not pre-etched was extremely poor, as none of these bond strengths exceeded 12.11 MPa. Furthermore these results were extremely low when compared with the findings of other researchers.37-41 This discrepancy can be attributed to the inconsistency of in vitro bond testing protocols between researchers.5,7,22,42

A limitation of this study that must be mentioned is that testing was conducted on both molars and premolars, without any restriction on the type of posterior tooth (e.g. third molars only) or the age of the tooth/patients. Another limitation is the large intra-sample variability between the groups involving bonding to dentine. This may be indicative of random error during specimen preparation within these groups or perhaps structural differences in dentine particularly between molars and premolars. Recommendations regarding the performance of these materials in relation to dentine will therefore be reserved.

CONCLUSIONS

Within the limits of this study, the following conclusions were reached:

- When used on tooth substrates that were not pre-etched, the in vitro adhesion of Filtek Silorane composite, together with its dedicated sixth generation type I bonding agent Silorane System Adhesive, is poor. Pre-etching of both uncut and cut enamel with 34% phosphoric acid for 20 seconds significantly improved the mean shear bond strengths on un-cut enamel by 61% and cut enamel by 76%. Pre-etching of dentine with 34% phosphoric acid for 15 seconds also significantly improved the mean shear bond strength by 139%.
- The methacrylate-based composite Filtek Supreme XTE together with the seventh generation bonding agent Scotchbond Universal Adhesive when used on tooth substrates that were not pre-etched showed acceptable in vitro adhesion. Pre-etching of uncut enamel with 34% phosphoric acid for 20 seconds significantly improved the mean shear bond strength by 57%. Phosphoric acid pre-etching of cut enamel improved the mean shear bond strength of the Filtek Supreme XTE/Scotchbond Universal system by only 25%, which is not significant. In contrast to the silorane-based system, pre-etching of dentine with 34% phosphoric acid for 15 seconds when using Scotchbond Universal Adhesive resulted in a 22% drop in shear bond strength, which, however, is not statistically significant.
- Based on the results of this in vitro study, it would be prudent to conclude that the effect of pre-etching on SBS to uncut enamel, cut enamel, and dentine is product specific.
RECOMMENDATIONS

Within the limits of this study, the following recommendations are made:

- The in vitro SBS performance of the novel low shrinkage composite system Filtek Silorane and Silorane System Adhesive is of concern when used on tooth substrates without pre-etching. Additional clinical/in vivo studies are needed to better evaluate the success rate of this material.

- In a clinical situation, phosphoric acid pre-etching of uncut enamel and cut enamel before the application of the self-etching primer is recommended.

- The in vitro SBS performance of Scotchbond Universal Adhesive and Filtek Supreme XTE when used on tooth substrates that were not pre-etched was acceptable. However, the authors concur with the recommendations of the manufacturer, regarding phosphoric acid pre-etching of uncut enamel.

- The clinical significance of this study is highlighted when it comes to the restoration of cavities that are dependent on strong bonds to enamel, such as large Class IV incisal fractures; Class V cavities with cavo-surface margins in enamel; and high C-factor cavities. In such clinical situations and when mild self-etching adhesives are used, the authors recommend selective pre-etching of enamel to improve bond strengths and to reduce marginal defects and staining.

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41. Devarasa GM, Subba Reddy VV, Chaitra NL, Swarna, YM. Self-etching adhesive on intact enamel, with and without pre-

Perceived stress among dental students at the University of the Western Cape

ABSTRACT
Introduction: A high prevalence of stress among dental students has been reported.

Aim: To determine perceived stress among dental students at the University of the Western Cape.

Method: A self-administered questionnaire to students (n=411) was used to collect data. Variables measured included demographic characteristics of students and their perceived stress in the dental environment using the Dental Environment Stress (DES) survey and the Maslach Burnout Inventory (MBI).

Results: The response rate was 78%. Respondents were in the 18 to 21 age category; mostly female (n=207); multilingual, with 63% having English as their home language. Huge problems identified from the DES were lack of time for relaxation, inadequate breaks during the day, fear of failing a year or module, work load, inconsistency between clinical supervisors and patients being late for appointments. The MBI found high EE (28.91), low DP (7.13) and high PA (30.06) scores. Fourth year students experienced the highest degree of stress on the DES and MBI.

Conclusion: Stressors identified are consistent with international dental literature. Levels of stress increased over the academic years and peaked in the fourth year. Stressors experienced may impact student academic and future professional development, motivating a need for intervention at Faculty level.

INTRODUCTION
Stress among students has been well documented in the international arena with a high prevalence of stress identified among dental students. Some of the stressors identified in these studies include the learning environment, fear of failure, heavy workload, difficulties in dealing with patients and with transitions in curricula and challenging relationships with academic staff. Differences in student experiences of stress were related to geographical and educational background, culture and ethnicity. There are sparse published reports on stress among dental students in the South African context.

It has been shown that students’ perceived stress increases over their successive academic years with detrimental effects on their performance and health. A potential long-term consequence of occupational stress is professional burnout. A significant aspect of the burnout syndrome is “increased feelings of becoming emotionally exhausted”, with other characteristics being “the development of a negative cynical attitude towards one’s clients” and “a tendency to evaluate oneself and one’s accomplishments negatively.” A potential for burnout among dental students has been reported.

In contrast to international studies, Hendricks et al. found that dental students at the University of the Western Cape (UWC), South Africa ranked non-academic stressors higher than academic stressors. The investigators suggested that their questionnaire may not have been “sensitive enough to identify the determinants of stress within the Apartheid educational structures”. The current post-Apartheid cohort of dental students at UWC constitutes a diverse group. Therefore, it would be useful to explore their perceived stressors within a global context.

AIM AND OBJECTIVES
The aim of this study was to determine perceived stressors among dental students at the UWC. The objectives were to determine the demographic characteristics, stressors experienced, effects of stressors on students and whether major stressors varied across academic years.
**METHODS**

A cross-sectional, descriptive study of dental students (N=411) was conducted in 2012. Data was collected by means of a self-administered questionnaire using a quantitative approach. The questionnaire was distributed to students in their classrooms and completed questionnaires were collected by the researchers.

The three parameters measured were: 1) demographic characteristics, 2) burnout, using the Maslach Burnout Inventory (MBI) and 3) sources of stress, using a modified Dental Environment Survey (DES). The MBI [20] and DES [4] questionnaires were adapted appropriately for the local and academic environment.

The MBI consisted of 22 statements each scored on a seven point Likert scale ranging from 0 (never) to 6 (every day) which is divided into three scales namely emotional exhaustion (EE), personal accomplishment (PA) and depersonalisation (DP). Mean scores were calculated for the three subscales and these subscales were then categorised as low, average or high. High scores on EE (≥ 27) and DP (≥ 10) and low scores on PA (≥ 40) are indicative for burnout in the occupational subgroup of medical workers (MBI-Human Services Survey (MBI HSS)). [21]

The DES consisted of 79 statements enquiring about: the study environment (n=27), theoretical (n=14), preclinical (n=13) and clinical aspects (n=25) of the educational environment. Students were required to indicate whether each statement posed “no problem”, “a small problem” or “a huge problem” in terms of their studies. Preclinical and clinical components were completed as applicable to the year of study.

A pilot study was conducted with 10 students and appropriate minor modifications made to the questionnaire. Data was entered and analysed into IBM SPSS version 21. Descriptive statistics included frequency distributions; means and standard deviations. The Wilcoxon Rank sum test or the Kruskal-Wallis test (when there were more than two groups) was used to compare year groups.

Ethical approval was obtained from the University Research and Ethics committee. Informed consent was obtained from the participants. This project was funded by the University of the Western Cape.

<table>
<thead>
<tr>
<th>Stressors per category (DES)</th>
<th>Percentages of responses to a “huge problem”</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Overall score</td>
</tr>
<tr>
<td><strong>Dental environment</strong></td>
<td></td>
</tr>
<tr>
<td>1. Lack of time for relaxation</td>
<td>45</td>
</tr>
<tr>
<td>2. Inadequate breaks</td>
<td>43.7</td>
</tr>
<tr>
<td>3. Treated as immature and irresponsible</td>
<td>40.3</td>
</tr>
<tr>
<td>4. Neglect for personal life</td>
<td>37.7</td>
</tr>
<tr>
<td>5. Worrying about physical health</td>
<td>29.2</td>
</tr>
<tr>
<td>Mean (dental environment)</td>
<td>39.18</td>
</tr>
<tr>
<td><strong>Theory</strong></td>
<td></td>
</tr>
<tr>
<td>1. Fear of failing a module/year</td>
<td>57.5</td>
</tr>
<tr>
<td>2. Overloaded feeling due to large number of modules</td>
<td>50</td>
</tr>
<tr>
<td>3. Having a lecture/clinic/lab before assessment</td>
<td>48.1</td>
</tr>
<tr>
<td>4. Amount of study load</td>
<td>47.8</td>
</tr>
<tr>
<td>5. Feelings that success is determined by factors not in their control</td>
<td>36.5</td>
</tr>
<tr>
<td>Mean (theory)</td>
<td>47.98</td>
</tr>
<tr>
<td><strong>Preclinical</strong></td>
<td></td>
</tr>
<tr>
<td>1. Inconsistency between supervisors/teachers</td>
<td>31.4</td>
</tr>
<tr>
<td>2. Fear of making mistakes</td>
<td>31.1</td>
</tr>
<tr>
<td>3. Lack of time to practice</td>
<td>25.8</td>
</tr>
<tr>
<td>4. Number of supervisors in relation to students</td>
<td>21.4</td>
</tr>
<tr>
<td>5. Inability to replace instruments</td>
<td>20.1</td>
</tr>
<tr>
<td>Mean (preclinical)</td>
<td>25.96</td>
</tr>
<tr>
<td><strong>Clinical</strong></td>
<td></td>
</tr>
<tr>
<td>1. Patients being late / missing appointments</td>
<td>38.7</td>
</tr>
<tr>
<td>2. Fear of being criticised in front of patients</td>
<td>35</td>
</tr>
<tr>
<td>3. Fear of being unable to catch up with clinical requirements</td>
<td>33.3</td>
</tr>
<tr>
<td>4. Responsibility to get suitable patients</td>
<td>27</td>
</tr>
<tr>
<td>5. Number of assigned quotas</td>
<td>25.8</td>
</tr>
<tr>
<td>Mean (clinical)</td>
<td>31.96</td>
</tr>
</tbody>
</table>
RESULTS
Demographics of respondents
The response rate was 78% (n = 318). Respondents were primarily in the 18 to 21 age category; mostly female (n=207); multilingual with 63% having English, the medium of education of the University, as their home language.

Respondents were primarily from the Western Cape Province (51%), Kwa-Zulu Natal (18.9%) and the Eastern Cape (13.2%). Most (77%) had attended public schooling. A third (33%) lived with family while the remainder lived in University residence or on their own.

Student response to the DES questionnaire
The five most frequent stressors in each category of the DES were ranked (Table 1). The theoretical component of the DES scored highest overall (mean = 47.98%) in terms of huge problems compared with the other categories.

There was considerable variation across the year groups in terms of stressors experienced. Fourth year students scored highest in all components except in the clinical component where there was a marginal difference between fourth and fifth year groups.

Additional stressors reported as huge problems were: lack of effective lectures/teaching, by first years (49%); lack of self-motivation to study, by second (39.2%) and fourth years (47.9%); scheduling of continuous assessments, by third years (46.1%); lack of student input into faculty decision making and lack of response by faculty administration to needs of students, by fourth and fifth years (40-50%). In the fourth and fifth years, additional stressors included clinical supervisor/assistant student ratio and inconsistent clinical feedback (ranging from 41 to 51%) (Table 2).

Student response to Maslach Burnout Inventory (MBI)
The means for statements in each subscale of the MBI are ranked in descending order (Table 3). The overall mean values (mean, SD) for EE, PA and DP were: 28.91 (10.28), 30.06 (7.51) and 7.13(6.03) respectively. There were significant differences across the year groups for subscales EE and DP. The fourth year group was significantly different compared with the first, second and third years for EE (p<0.001) and DP (p<0.0001). Students living on their own differed from those living with parents or at university residence in the subscale DP (p<0.001). (Table 3).

MBI Subscales per year group
High scores on EE (≥ 27) and DP (≥ 10) and low scores on PA (≥ 40)) are indicative for burn-out (MBI-Human Services Survey (MBI HSS).21

The percentage of students in each sub-scale per year group varied (Table 4). Although EE, the key dimension of burnout, is rated as high for all years except the second year group, none of the year groups met the criteria

<table>
<thead>
<tr>
<th>Stressors according to the DES</th>
<th>Percentage of class</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dental environment</td>
<td></td>
</tr>
<tr>
<td>1. Having financial responsibilities</td>
<td>19</td>
</tr>
<tr>
<td>2. Lack of confidence to be a successful dentist</td>
<td>14.3</td>
</tr>
<tr>
<td>3. Lack of home atmosphere/ feeling home sick</td>
<td>14.3</td>
</tr>
<tr>
<td>4. Amount of cheating in dental school</td>
<td>14.3</td>
</tr>
<tr>
<td>5. Competition between grades</td>
<td>11.1</td>
</tr>
<tr>
<td>6. Conflict between classmates about organization/logistical issues</td>
<td>11.1</td>
</tr>
<tr>
<td>7. Lack of (faculty ) administrative response to my needs</td>
<td>6.3</td>
</tr>
<tr>
<td>8. Lack of student input in faculty decision making</td>
<td>9.7</td>
</tr>
<tr>
<td>Theory</td>
<td></td>
</tr>
<tr>
<td>1. Lack of effective lectures/teaching</td>
<td>49.2</td>
</tr>
<tr>
<td>2. Lack of self-motivation to study</td>
<td>36.5</td>
</tr>
<tr>
<td>3. Spacing of continuous assessment throughout the year</td>
<td>20.6</td>
</tr>
<tr>
<td>Preclinical</td>
<td></td>
</tr>
<tr>
<td>1. Inability to afford required instruments</td>
<td>27.5</td>
</tr>
<tr>
<td>2. Meeting requirements of preclinical components</td>
<td>19</td>
</tr>
<tr>
<td>3. Manner/style of teaching preclinical component</td>
<td>8</td>
</tr>
<tr>
<td>4. Receiving criticism about my progress</td>
<td>13.8</td>
</tr>
<tr>
<td>5. Limited cooperation from laboratory/technician staff</td>
<td>10</td>
</tr>
<tr>
<td>Clinical</td>
<td></td>
</tr>
<tr>
<td>1. Patients attitudes towards dental students</td>
<td>20.3</td>
</tr>
<tr>
<td>2. Lack of cleanliness and hygiene in clinics</td>
<td>17.2</td>
</tr>
<tr>
<td>3. Fear of receiving criticism about my work</td>
<td>16.9</td>
</tr>
<tr>
<td>4. Conflict between department/ supervisor expectations and available clinical time</td>
<td>15.5</td>
</tr>
<tr>
<td>5. Number of clinical supervisors in relation to number of students</td>
<td>10.8</td>
</tr>
<tr>
<td>6. Inconsistency of feedback between different supervisors</td>
<td>16.9</td>
</tr>
<tr>
<td>7. Inadequate number of dental assistants to student numbers</td>
<td>12.1</td>
</tr>
</tbody>
</table>

(Figures in bold indicate that the data for that year is significantly different from other year groups.)
considered as actually experiencing burnout. However, the fourth year group appeared to be at greater risk for burnout compared with the other groups.

**DISCUSSION**

This study, based on the modified DES questionnaire of Al-Saleh et al., reported similar findings. However, the overall “dental environment and theory” components in this study were scored as more stressful than the “clinical” components.

Within the dental environment component, lack of time for relaxation was scored highest, as it is also in studies reported in the international literature. Non-academic stressors (a shortage of extra-curricular time and inadequate time for social activities) were also reported as the highest stressor among a UWC study population in 1994. Of interest is that fourth years scored this item highest whilst it was the third years who reported that opinion in other studies. Four of the five top stressors identified as “personal or administrative problems” by Al-Saleh et al. were also reported in this study. These results suggest that stressors within the dental environment may be experienced universally. However, in modifying the DES questionnaire, one has to take cognisance of socio-cultural differences. A top stressor: “responsibility of having children”, identified by Al-Saleh et al., was excluded in the current study due to the profile of UWC students.

Tables 1 and 2 show that students across the year groups experience stressors differently. This could be attributed to the respective stages reached in the curriculum, the demands of the curricula and the maturity of students in coping with academic and personal demands.

Overall the stressors in the dental environment, theory and preclinical components, were highest in fourth year. Sanders and Lushington found that among Australian dental students stress increased over time and peaked in the fourth year of study. The five year curriculum at UWC is structured such that first, second and third year students have mostly preclinical and didactic teaching, with a limited experience of the treatment of patients, which commences in the third year. In the fourth and fifth years all modules have clinical components.

Perceived stressors changed from the preclinical to clinical components depending on the year of study.

Patients being late for appointments posed a huge problem, leading possibly to an inability to catch up with clinical work and failure to complete clinical requirements on time. It is the responsibility of students to find and book appropriate patients to satisfy their clinical requirements. This appears to be a major concern which can, however, be addressed by appropriate screening of patients and referral between departments in the Faculty.

### The Maslach Burnout Inventory

The MBI showed that overall subscale scores do not place dental students at risk for burnout. However, the high EE scores for all, except second years, are a cause for concern. High EE scores in dental students have also been reported by Gorter et al. and Pöhlmann et al. A longitudinal study of European dental schools found the number of students that scored high in the EE dimension increased from 22% in their first year to 39% in their fifth year. The present study concurs with the literature which indicates that the prevalence of emotional exhaustion among dental students is of concern in view of EE being a key dimension of burnout.

Fourth year students appear to be at greatest risk as they meet two of the three criteria (high EE and high DP) indicative of burnout (Table 4). A high DP is characterised by emotional detachment from the needs of patients and peers. Pöhlmann et al. suggest that high DP scores may reflect student insecurity in dealing with patients in an environment where treatment demands are high. In addition, a lack of social competence manifests in relationships on a personal and a professional level. During the clinical period, fourth and fifth years experienced emotional exhaustion (10%), a severe lack of accomplishment (17%) and high depersonalisation (28%). Emotional exhaustion was explained by factors such as:

#### Table 3: Maslach Burnout Inventory (MBI)

<table>
<thead>
<tr>
<th>Statement</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Emotional Exhaustion (EE)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 I feel used up/worn out at the end of my day at university</td>
<td>4.61</td>
<td>1.30</td>
</tr>
<tr>
<td>2 I feel fatigued/tired when I get up in the morning and have to face another day at university</td>
<td>4.42</td>
<td>1.49</td>
</tr>
<tr>
<td>3 I feel emotionally drained/exhausted from my studies</td>
<td>4.31</td>
<td>1.47</td>
</tr>
<tr>
<td>4 I feel burnt out from my studies</td>
<td>3.98</td>
<td>1.57</td>
</tr>
<tr>
<td>5 I feel frustrated by my studies</td>
<td>3.63</td>
<td>1.69</td>
</tr>
<tr>
<td>6 I feel that I am working too hard on my studies</td>
<td>2.83</td>
<td>1.91</td>
</tr>
<tr>
<td>7 I feel that I am at the end of my rope</td>
<td>2.12</td>
<td>1.99</td>
</tr>
<tr>
<td>8 Interacting with people all day is really a strain for me</td>
<td>1.67</td>
<td>1.79</td>
</tr>
<tr>
<td>9 Interacting with people directly puts too much stress on me</td>
<td>1.33</td>
<td>1.63</td>
</tr>
<tr>
<td><strong>Personal Achievement (PA)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 I can easily understand how my patients and other students feel about things</td>
<td>4.67</td>
<td>1.36</td>
</tr>
<tr>
<td>2 I can easily create a relaxed atmosphere with my patients and other students</td>
<td>4.18</td>
<td>1.67</td>
</tr>
<tr>
<td>3 I deal very effectively with the problems of my patients and other students</td>
<td>4.02</td>
<td>1.58</td>
</tr>
<tr>
<td>4 I feel I’m positively influencing other people’s lives through my studies</td>
<td>3.86</td>
<td>1.74</td>
</tr>
<tr>
<td>5 I have accomplished many worthwhile things in my studies</td>
<td>3.74</td>
<td>1.61</td>
</tr>
<tr>
<td>6 I feel exhilarated/inspired after working closely with my patients and other students</td>
<td>3.58</td>
<td>1.63</td>
</tr>
<tr>
<td>7 In my studies, I deal with emotional problems very calmly</td>
<td>3.32</td>
<td>1.82</td>
</tr>
<tr>
<td>8 I feel very energetic</td>
<td>2.59</td>
<td>1.72</td>
</tr>
<tr>
<td><strong>Depersonalisation (DP)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 I worry that my studies are hardening me emotionally</td>
<td>2.48</td>
<td>2.14</td>
</tr>
<tr>
<td>2 I have become more callous/uncaring towards people since I started my studies</td>
<td>1.45</td>
<td>1.92</td>
</tr>
<tr>
<td>3 I feel that I treat some patients and other students as if they were impersonal objects</td>
<td>1.19</td>
<td>1.66</td>
</tr>
<tr>
<td>4 I feel that patients and other students blame me for some of their problems</td>
<td>1.14</td>
<td>1.54</td>
</tr>
<tr>
<td>5 I don’t really care what happens to some patients and other students</td>
<td>0.92</td>
<td>1.46</td>
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as lack of leisure time (30%), examination anxiety (10%) and the transition stress of entering the clinical phase of training (4%).

Similarly, a lack of leisure time, worrying about physical health, fear of failing, and patients being late were identified as huge problems in the current study. Campos et al., using the MBI student survey (SS), identified burnout syndrome in 17% of dental students. The authors found a significant relationship between the prevalence of burnout syndrome and the student’s academic performance, use of medication because of studies and thoughts of dropping their course. A lack of motivation to study was reported by 47.9% of fourth year students in the current study.

The fact that all groups scored high on PA, with scores ranging from 57%-70%, suggest that most UWC dental students evaluate themselves and their accomplishments positively, in spite of feelings of emotional exhaustion. A positive shift in EE, particularly in the first and third years may result in a ripple effect on the subsequent years. High levels of PA combined with low levels of EE and DP is indicative of ‘engagement with work’ which may be a goal to work towards for interventions.

The nature of dentistry as a profession provides for multiple stressors for the future dentist in terms of the patient, staff, equipment and other factors. Gorter et al., found that dentists with a high risk for burnout also report health complaints to a greater extent than dentists with a low risk for burnout; dentists with a high burnout risk also report an unhealthier lifestyle than dentists with a low burnout risk. There is evidence to suggest that the concerns of clinical students echo those of qualified practitioners. Therefore, the results of this study should be seen and acted upon in the context of the education and training of future dentists.

CONCLUSION

This study found that dental students at UWC experience stress to an extent similar to that reported in studies appearing in the international dental literature. The level of stress increased over the academic years and peaked in the fourth year. These stressors may impact student academic performance and future professional development, motivating a need for intervention at a Faculty level.

References

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22. Morse Z, Dravo U. Stress levels of dental students at the Fiji School of Medicine, Eur J Dent Educ 2007; 11:99-103.
A tongue ring barbell shank in the floor of the mouth: an incidental finding by panoramic and cephalometric radiographs - a case report and review of literature

INTRODUCTION
Body adornment in the form of piercing has increased in popularity especially amongst young people in westernised societies. Body piercing has a long history with the most pierced areas being the navel, lip, tongue, earlobe, eyebrows and genitalia. Health professionals are likely to see an increase in complications of these piercings as their popularity increases.

Piercing of the tongue is usually performed in the midline of the tongue anterior to lingual frenum. A barbell shank of about 1.8cm must be placed first in the tongue to accommodate the initial swelling that normally occurs after piercing. This is then followed by the insertion of a shorter barbell shank after healing. The procedure is usually performed without anaesthesia. The tongue is protruded using a clamp and is then pierced by a needle bearing a gauge equal to that of the barbell stem.

CASE REPORT
A 20 year old female presented at the MEDUNSA Oral Health Centre with complaints of malocclusion. Her medical history was uneventful, but on her dental history she indicated that she had “braces” at the age of 12 and whilst eating an apple the braces had come out and she had never attended for follow-up. She then later confirmed that it was a maxillary Hawley appliance that she had and that it had broken in less than a year. Lateral cephalometric examination revealed a radiologically-dense rod-like structure superimposed on the roots of tooth 45. The soft tissue location in the tongue and floor of mouth was confirmed on panoramic view. A hard object was palpated in the sublingual area directly behind the lingual frenum and was too thick and straight to have been an orthodontic wire from a broken Hawley appliance. The patient initially denied knowledge of the object but later admitted to a failed tongue piercing procedure. She finally admitted to having gone to the tongue piercing parlour where an unsuccessful attempt had been made to pierce her tongue.

DISCUSSION
Tongue piercing complications are categorised as acute or chronic. Acute complications include tongue swelling, pain, changes of speech and foreign material rejection especially if the metals used contain nickel. Less frequently experienced symptoms include generation of a galvanic current between barbell and metallic dental restorations, infection, airway obstruction due to trauma and obstruction of the airway by the jewellery as well as prolonged hemorrhage. In our case the rod was an incidental finding on routine radiographs and was not the source of the patient’s main complaint. The metal was found on the sublingual folds just behind the lingual frenum, and had projected a ghost image on the radiographs. The patient was referred for surgical excision of the foreign object which consisted of a metal rod about 2cm in length, surrounded by fibrotic tissue (Figure 1).
Chronic complications of tongue piercing include trauma to the teeth, trauma to the gingiva and localised tissue overgrowth.\textsuperscript{3,12,13} There have been a few similar reports on jewellery becoming embedded in the oral soft tissues of the patients.\textsuperscript{13}

**CONCLUSION**

Strict follow up is essential of any strange and unexplained objects that are found coincidentally through radiographic examination during dental treatment.

**Conflict of interest:** None declared.

**References**

A 57-year-old male patient presented to the Oral Medicine Clinic with a one-month history of painful macroglossia associated with difficulty in speaking and swallowing. The patient complained of recent weight loss and chronic fatigue. Intra-oral examination showed the tongue to be enlarged with conspicuous nodules on the lateral borders (Figure 1). It had a multinodular, firm consistency on palpation. An incisional biopsy from the right lateral area of the tongue was submitted for histology.

Microscopic examination of the biopsy specimen showed a portion of soft tissue surfaced by focally ulcerated stratified squamous epithelium. The ulcer bed comprised inflamed granulation tissue with a superficial fibrinopurulent surface membrane. Within the lamina propria and extending to the deep aspect of the biopsy specimen was evidence of an amorphous eosinophilic proteinaceous material deposited extracellularly. Scattered between the deposits were occasional small blood vessels and a patchy chronic inflammatory cell infiltrate (Figure 2). The proteinaceous material stained a light salmon pink colour with Congo red staining when visualised by light microscopy (Figure 3). Polarised light showed the deposits to have an apple-green birefringence while an immunofluorescence labelling with Thioflavin-t was also positive (Figure 4). A diagnosis of amyloidosis was therefore made.

Following the histological diagnosis in this case, the patient was referred for systemic work-up which included a bone scan, serum electro- and immunophoresis and urinalysis. A bone marrow trephine biopsy confirmed the presence of sheets of neoplastic plasma cells in keeping with multiple myeloma. The patient is currently receiving chemotherapy although his general condition has deteriorated markedly.

**DISCUSSION**

Amyloidosis represents deposition of abnormally folded fibrillar proteins. Isolated tongue involvement is considerably rare, with most cases representing systemic involvement secondary to an immune dyscrasia. The head and neck region is involved in 12 to 90% of cases of systemic amyloidosis with deposition occurring frequently in the oral cavity, pharynx, larynx, salivary glands and orbital sinuses. The tongue is the most commonly involved intraoral site, however, involvement of the gingiva, palate and lips has also been documented. The accumulation of these extra-
Amyloid is broadly classified as systemic or localised. Systemic amyloidosis affects multiple tissue sites and organs in the body and is aetiologically divided into primary, secondary and hereditary forms. An acquired form as a result of haemodialysis is also included in this group. Primary amyloidosis represents the production of amyloid light chain proteins (AL) in association with plasma cell dyscrasias and multiple myeloma. In such cases increased amounts of immunoglobulin light chains are produced by the lesional plasma cells.4 Amyloidosis is reported in 5 to 15% of patients with multiple myeloma.4 Secondary amyloidosis represents a form of non-immunoglobulin derived protein (AA type), usually produced in increased amounts by the liver in chronic inflammatory disease such as osteoarthritis, tuberculosis, rheumatoid arthritis and Crohn’s disease.7 Hereditary amyloidosis is associated with genetic mutations which result in abnormal protein production and systemic deposition.6

Localised amyloidosis is far rarer and represents the deposition of amyloid which is limited to a single organ or tissue. Amyloid of this type is often associated with endocrine neoplasms where it is derived from polypeptide hormones or as a result of aging where transthyretin protein is frequently deposited in the heart.6,7

Head and neck involvement by amyloid deposition may occur in both systemic and localised forms of disease although it is exceptionally rare in the latter form.1 Amyloidosis of the tongue is typically associated with primary systemic amyloidosis in the setting of an immune dyscrasia. The pathogenesis of amyloidosis in this scenario relates to the monoclonal production of immunoglobulin light chains by the lesional plasma cells. Proteolytic enzymes derived from macrophages in these disease processes convert the light chains into fibrillary proteins which are deposited systemically in the tissues.4,6

The excess light chain production results in excretion of Bence-Jones proteins in the urine and may be detected by both electro- and immune - phoresis. The lesional plasma cells proliferate within the bone marrow at the expense of the other haematopoietic elements resulting in anaemia, thrombocytopenia and leukopenia. Patients will therefore be susceptible to infections, fatigue and have a tendency to bruise easily. The multifocal punched out skeletal lesions further predispose the patient to bone pain and pathological fracture.5,7 Deposition of amyloid in the tongue is slowly progressive and is recognised as one of the important causes of macroglossia. Continued deposition will result in restricted tongue movement and in the dentate patient, pressure of an enlarged tongue against the occlusal surfaces of the adjacent teeth results in the characteristic indentations or creations as noted in this case. Patients often have a loss of peri-orbital and labial soft tissue elasticity due to the subcutaneous and submucosal deposition of amyloid proteins.6

The clinical differential diagnosis in this patient would include other causes of macroglossia such as lymphangioma, haemangioma, acromegaly, hypothyroidism, syndromic macroglossia and tumour infiltration.8 The characteristic features of tongue rigidity, a waxy firm cut-surface of the biopsy specimen as well as the typical microscopic features as noted in the present case are fairly diagnostic of amyloid deposition.

CONCLUSION
It is absolutely imperative to perform a systemic work-up and investigation in any case of amyloidosis in order to distinguish systemic from localised disease as well as to target the underlying cause in each case. The localised and systemic forms of disease have vastly different prognoses and therapeutic management.

References
Ethical responsibilities when using locum tenens

**Locum tenens** is usually a position that is offered when a practitioner in private practice is going on holiday, attending a congress, taking study leave or is absent from practice due to illness or other reason, and therefore the appointment is of short duration. The term *locum tenens* originates from the Middle Ages and means “one holding a place” and in the 1970s was generally used by medical facilities where there was a shortage of medical doctors. Remuneration is usually based on a percentage of fees earned, or a set salary or a small basic salary coupled with a percentage of gross earnings above an agreed figure. Often when patients realise that their dentist will be returning in the near future, many prefer to await their return rather than being treated by a stranger, therefore it is preferable for a *locum* to accept a fixed salary or a basic salary plus commission.

In many instances *locums* are appointed by dental practitioners without their thinking through the legal consequences of the appointment. In legal terms when something goes wrong either with a patient or with the practice, it is very important to establish whether a *locum* was appointed as an employee or as an independent contractor for the period that he or she has to stand in for the practitioner. The exact position of a *locum tenens* will depend on the contract that he or she has with the practice owner. In some instances he or she would be considered as a ‘servant’ (employee), and in others as an ‘agent of the owner’ (independent contractor). It is clear, however, that in any instance a *locum* could be sued for his/her own negligent action, because of an individual’s liability for his or her own acts.

If a *locum* is appointed as an employee, the rights of employees under the Labour Relations Act and the Basic Conditions of Employment Act are important considerations depending on the amount of remuneration the *locum* will receive. In addition, the dental practitioner (employer) could be held liable for any unlawful and/or negligent conduct of the *locum* (employee) while he/she is performing a duty for the practice. This responsibility is termed ‘vicarious liability’. It is a doctrine of liability without fault, meaning one person is held liable to a third party for the unlawful act of another. In the context of an employment relationship, the practitioner can be held liable for the unlawful acts of an employee – or the dentist who employs a *locum* as an employee can be held liable for the unlawful or unprofessional acts and omissions of the *locum* whether or not they were acting according to instructions given.

However, although an employer carries this liability for the acts of his/her employees, every individual remains liable for his or her own acts, and thus a claim of negligence could be brought against the employee, the employer or both. If a *locum* is appointed as an independent contractor, labour legislation does not apply at all, and the doctrine of vicarious liability becomes applicable only if an incompetent *locum* is appointed or, as stated earlier, the *locum* acts in such a way as to cause prejudice to third parties. The *locum* as an independent contractor is hired solely to provide services as a substitute clinician for a limited period of time. While assigned practice hours may exist, such clinicians (independent contractors) exercise their own professional judgement in treating patients. It thus seems a much safer option for a dental practitioner to appoint a *locum* at all times as an independent contractor and never as an employee. If the *locum* is appointed as an employee, the dental practitioner who hired or employed the *locum* may very well be liable for any improper acts or omissions by the *locum*.

The Health Professions Council of South Africa has clear guidelines regarding the appointment and use of *locum tenens* under the principle of duty of care of the health professions. To ensure patients’ best interests or well-being, practitioners cannot “employ any intern, health care provider in community service, or health care practitioner with restricted registration with the HPCSA, as a *locum tenens* – or otherwise - in their own or any associated health care practice”. Dental practitioners should take care when appointing a *locum* to ensure that the applicant is duly qualified and registered. The HPCSA has taken disciplinary action and meted out hefty fines and temporary suspensions against some practitioners who have permitted unqualified or unregistered persons to act as *locum tenens* (whether appointed as employees or independent contractors).

There is not much guidance given either by the Health Professions Act or the HPCSA Ethical Rules regarding
whether the appointment of a locum should either be as an employee or as an independent contractor. It is up to the practitioner (employer) and the locum to determine the contents of the contract of employment. As mentioned above it is important to distinguish between an ‘employee’ and an ‘independent contractor’ since the law attaches different consequences to either appointment. If a locum is appointed as an employee, labour legislation will be applicable to the contract of employment, which will not be the case where an independent contractor is involved.1

The Health Professions Act6 does not address the appointment of a locum directly; neither does the Act indicate whether a locum should be appointed as an employee or an independent contractor. Section 9 of the Ethical Rules of Conduct for Practitioners registered under the Health Professions Act, 1974 determines the following regarding locums: a practitioner shall employ as a professional assistant or locum tenens, or in any other contractual capacity and, in the case of locum tenens for a period not exceeding six months, only a person –
(a) who is registered under the Act to practise;
(b) whose name currently appears on the register kept by the registrar in terms of section 18 of the Act; and
(c) who is not suspended from practising his or her profession.

Section 18 of the same Rules states that:
(1) A practitioner shall accept a professional appointment or employment from employers approved by Council only in accordance with a written contract of appointment or employment which is drawn up on a basis which is in the interest of the public and the profession.
(2) A written contract of appointment or employment referred to in sub rule (1) shall be made available to the Council at its request.

The Ethical Rules to the Act thus determine that a locum cannot be appointed for a period exceeding six months and that the locum is registered as a health practitioner with the HPCSA. Ideally the contract of appointment should be in writing and if a member of the HPCSA would like to see such a contract of appointment, it should be made available. If there is no written contract to stipulate whether the locum is an employee or an independent contractor, this complicates matters if a dispute arises. In such an instance the courts will fall back on the reality test to determine the position of the locum. The reality test is applied by the courts to determine whether an employee or an independent contractor is involved in a dispute. Previously the courts relied on other common law tests but they proved to be inadequate over time.7

When a patient seeks care from a professional person, it would be a reasonable expectation that the person was trained properly, appropriately skilled and was competent to carry to deliver such care. This is often described a ‘duty of care’ owed by the provider to the recipient. An extension of the duty of care is the presumption that an appropriate standard of care will be provided.7 In the practice of dentistry there is a more benevolent and protective aspect of one’s duty to care both in terms of an expectation that one will always try for the best for the patient and also with regard to the ethical principle of primum non nocere – ‘first do no harm’. Therefore if the legal aspect of one’s duty of care is concerned with reasonable skill and care, the ethical aspect expects us to put the patient’s best interest first and certainly above one’s own personal and professional interest.

The Consumer Protection Act8 applies to every transaction occurring in South Africa involving the supply of goods or services in exchange for consideration, unless the transaction is exempted from the application of the Act. For the purposes of the Act a patient is considered a “consumer”. A dental practitioner is seen as a “service provider”. “Service” in a dental context is a consultation with a dental practitioner, the dental advice rendered by such a practitioner, or any dental intervention, such as an operation. The aim of the Act is to protect and develop the social and economic welfare of consumers, especially vulnerable consumers.

If a practitioner uses a locum, the practitioner must be cognisant of the fact that the locum becomes part of the supply chain and is a participant in the contract. Consumers who suffer any harm can sue anyone who is deemed part of the “supply chain” and this may include both the dental practitioner and locum. The effect of the Consumer Protection Act in a Health Professions context has not been tested in the courts yet, but inclusion of a clause regarding the Act in a contract with the locum, will ensure that he or she forms part of the supply chain should any action arise.

CONCLUDING REMARKS

It is the duty of the dental practitioner in private practice to inform all patients whenever a locum tenens is used. This could be part of the informed consent process, and it should be noted on the report by the locum when he or she actually sees the patient.1 In all cases it would be better for the practitioner to appoint a locum as an independent contractor, because the locum himself or herself would then be held liable for the alleged unlawful or unprofessional conduct. An independent contractor would have to face cases of delictual negligence on his or her own whereas the employee is “covered” by vicarious liability. Finally, contracts should be drawn up in writing and the Consumer Protection Act should also be included to the benefit of both the practitioner and the locum.

References

Readers are invited to submit ethical queries or dilemmas to Prof. S Naidoo, Department of Community Dentistry, Private Bag X1, Tygerberg 7505 or email: suenaidoo@uwc.ac.za
Below are clinical and radiographic images of a condition that may occur in about 1 in 1,000 live births. It is reportedly most common in the Japanese and least common in Negroes. What is your diagnosis?

**INTERPRETATION**

The above images are examples of cleft palate and cleft lip. After clubfoot, cleft lip and cleft palate are the most frequently encountered congenital deformities. Cleft palate is a defect in the continuity of the palate resulting from incomplete development or maturation of embryonal processes. It is often but not invariably accompanied by cleft lip. Cleft palate may be an isolated occurrence or may be part of various specific syndromes. Cleft palate varies greatly in severity and tissue involvement. The hard or soft palate, or a combination of both, can be affected. Frequently, clefts of the hard palate extend anteriorly through the alveolar ridge and lip, deviating to the right and/or left in the premaxilla. Sometimes, although much less often, the premaxillary defect is bilateral (Figs. A, B, C). When the alveolar ridge is affected, teeth in the region may be missing (Fig. D), deformed, or displaced, or supernumerary teeth can be present. The etiology is not completely understood, but heredity plays a role. Chromosomal abnormalities and exogenous factors are recognized as having etiologic impact, and a positive relationship between advancing age of parents and frequency of cleft has been demonstrated. On occasion only the soft palate or a bifid uvula is involved (Fig. E). In unilateral cases of combined total cleft lip and palate, the vomer is in most cases connected with the palatal plate of the non-affected side. In about half of cases, other developmental abnormalities are present. These include a variety of specific syndromes, congenital heart defects, polydactyly or syndactyly, hydrocephalus, spina bifida, and mental deficiency.

**References**

What’s new for the clinician?
Summaries of and excerpts from recently published papers

1. Toothbrushing and flossing behaviour in young adults—a video observation


Oral hygiene is a cornerstone of maintaining gingival and dental health, provided that the removal of plaque is sufficiently thorough. Despite the intensive efforts made in many settings to establish good oral hygiene performance, self-performed mechanical plaque removal often is not sufficiently effective, and clinicians observe daily that patients exhibit considerable amounts of plaque, even though these patients report performing oral hygiene routines. The cause of this discouraging finding is not well understood. The performance of oral hygiene procedures has been primarily investigated using levels of plaque as a surrogate parameter but was rarely verified by observational data, for instance, video filming.

Amongst the few observational studies of toothbrushing behaviour, it was noted that the time spent on brushing various areas of the mouth varied considerably and that the oral surfaces were rarely brushed. Subjects used more than one type of stroke, frequently alternated between brushed areas of the mouth, and often tended to move the toothbrush from the left to the right. These findings clearly show a marked difference between the recommendations for adequate toothbrushing (in particular, brushing systematically) and what was implemented in daily practice. These studies were published more than two decades ago and have not been repeated since.¹ Winterfeld and colleagues (2015)¹ reported on a study that sought to observe and analyze habitual brushing and flossing.

MATERIALS AND METHODS

This German-based study was a descriptive, cross-sectional, non-disguised observational study. Participants were inhabitants of Giessen (Hesse, Germany) and of the same age. From the register of residents, a random sample of subjects was drawn, aiming to obtain a final sample of 100 subjects. Included subjects were all born in 1992, in good general health (no mental or physical disability with the potential to influence oral hygiene), used a manual toothbrush and provided informed consent.

All procedures and conversations (e.g. telephone script, welcome/information/inclusion and explanation of video procedures) were standardized. The study was carried out by two investigators, who were trained and calibrated.

Participants performed their habitual oral hygiene in a separate prepared room (simulation of a washbasin bathroom) while standing in front of a parabolic mirror with an integrated video camera. A toothbrush with a short brushing head and medium bristle stiffness and floss that was 0.5 m long was offered, and participants were invited to clean their teeth as they did habitually in everyday life. They were left alone in the room, but they were aware of being filmed. There was no clock provided and no time restriction; toothpaste was not provided to simplify the analysis of the video.

The video recordings were analysed after data collection was complete using the observation software INTERACT. A count coding system for measuring continuous timed events was developed after several rounds of discussion with all persons involved in the project. Videos were coded exhaustively, meaning that every second of the observation session was coded using continuous timed-event behaviour sampling. Videos were coded in four passes as follows: In the first pass, the time of the start and stop of the brushing process were determined; in the second pass, the areas where the teeth were brushed were determined; and in the third pass, the types of brushing strokes were coded. A fourth pass of coding was performed if the participant flossed.

Basic characteristics of interest were brushing duration and the types of brushing strokes. More in-depth analysis focused on patterns of movements within the dentition, including the frequency of alternations between sextants and tooth surfaces. The dentition was divided into sextants (S1–S6) and three tooth surfaces (oral, occlusal and vestibular) that summed to 18 areas.

Measures of interest regarding flossing were whether subjects flossed, their flossing technique and the completeness of flossing interproximal spaces. The parameters used to analyse toothbrushing and flossing are described in Tables 1 and 2.

Intra-rater agreement was calculated in INTERACT, which offers the possibility to compare timed-event sequential data of multiple observers based on the kappa statistic.

V Yengopal: MChD (Community Dentistry) Stellenbosch. Department of Community Dentistry, School of Oral Health Sciences, University of the Witwatersrand. E-mail: Veerasamy.Yengopal@wits.ac.za.
RESULTS
Participants included 58 females and 43 males with a mean age of 18.9 ± 0.3 years. The overall response rate was 42%.

The mean total brushing duration was 162.5 ± 73.9s. The effective brushing duration was 156.0 ± 71.1s; 63% of the participants brushed for 2min or longer, and only 14% brushed less than 1.5min.

The effective brushing duration in the upper jaw was 75.9 ± 35.4s and, in the lower jaw, was 80.2 ± 38.3s (p ≤ 0.05). The right side was brushed for 52.0 ± 26.0s, the left side for 48.8 ± 26.0s, and the anterior area for 55.3 ± 29.0s (p < 0.05). Handedness had no significant impact. The vestibular surfaces were brushed more than twice as long (72.1 ± 31.8s) as the oral surfaces (27.1 ± 27.8s) (p ≤ 0.001).

Concerning completeness of brushing, except for the occlusal tooth surfaces, 26 participants reached all 12 areas of the dentition (the oral and vestibular surfaces of S1–S6); 36 brushed between 9 and 11 areas, and 39 brushed less than 9 areas.

Circular and horizontal strokes were predominant on the vestibular surfaces, whereas the oral surfaces were predominantly brushed with horizontal strokes in the posterior sextants and with vertical strokes in the anterior sextants.

Participants moved frequently between areas (45.1 ± 22.4 brushing events; upper tertile range was between 50 and 133 brushing events). The most frequent alternations between sextants occurred within a jaw. In the upper jaw, movements often changed from posterior to anterior and vice versa, whereas, in the lower jaw, changes often occurred between the posterior sextants and did not include the anterior area. Diagonal alternations or alternations between jaws were observed much less often; there was a frequency peak for movements between S6 and S1.

The alternations from one area to another were most frequently from (I) the anterior vestibular area to the left and right vestibular area; (II) from the left and right vestibular area to the anterior vestibular area and (III) from the right occlusal to the left occlusal and vice versa.

Almost half of the participants (n = 47) flossed. The flossing performance of five participants was not completely visible in the video recording. Of the remaining 42 participants, only five flossed all sextants completely; 26 flossed between one and five sextants completely, and 11 flossed only sporadically.

In the upper jaw, the anterior teeth were flossed completely more often (S2: 21 participants) than were the posterior teeth (S1: 12 participants; S3: 12 participants); this difference was not observed in the lower jaw (S4: 18 participants; S5: 18 participants; S6: 19 participants).

Two participants performed an adequate (see Table 2) flossing technique, whereas the others (n = 40) used an inadequate flossing technique.

Only one participant flossed all sextants completely and performed the technique defined as adequate.

CONCLUSION
The authors concluded that although the toothbrushing duration of young adults complied with international recommendations, toothbrushing was not complete in many subjects, and there was a striking neglect of the oral surfaces. Although circular and horizontal movements were used most often, there was intra-individual heterogeneity in the types of strokes at different areas of the dentition.

Subjects brushed with specific recurrent motion sequences that were very similar to those observed in studies published more than 30 years ago, indicating a strongly anchored brushing behaviour independent of oral hygiene education and socio-demographic background. Flossing was performed by almost half of the participants; however, only two subjects flossed according to the technique we defined as adequate, and only one of them flossed completely.

IMPLICATIONS FOR PRACTICE
These findings suggest that oral health professionals should continue to highlight the importance of proper oral hygiene instruction in their patients and demonstrate and monitor patient compliance to brushing and flossing protocols.

Reference

Table 1: Criteria defined for analysing toothbrushing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
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<tbody>
<tr>
<td>Total brushing duration</td>
<td>Time between the first contact of the toothbrush with teeth, and the last action of brushing.</td>
</tr>
<tr>
<td>Effective brushing duration</td>
<td>Effective time the toothbrush acts on the dentition without interruptions like rinsing, spitting or breaks.</td>
</tr>
<tr>
<td>Brushing strokes</td>
<td></td>
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<tr>
<td>Circling</td>
<td>a circular movement of the toothbrush's head and bristle ends on one or two (opposing) sextants.</td>
</tr>
<tr>
<td>Horizontal–linear</td>
<td>anterior and posterior movements of the toothbrush’s head and bristle ends in horizontal direction, parallel to the occlusal plane.</td>
</tr>
<tr>
<td>Vertical–linear</td>
<td>brushing movements from cervical to coronal or vice versa, parallel to the tooth axis.</td>
</tr>
<tr>
<td>Vertical–roll</td>
<td>vertical movement from cervical to coronal with an additional rotary movement of the toothbrush on its own axes.</td>
</tr>
<tr>
<td>Unspecific</td>
<td>if none of the previous brushing strokes could be assigned.</td>
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Table 2: Criteria defined for analysing flossing

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Description</th>
</tr>
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<tbody>
<tr>
<td>Floss was used</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Reached sextant</td>
<td>Complete: Each interproximal space in a sextant was approached at least once.</td>
</tr>
<tr>
<td></td>
<td>Incomplete: At least one interproximal space was approached.</td>
</tr>
<tr>
<td></td>
<td>Not reached: No interproximal space was approached.</td>
</tr>
<tr>
<td>Flossing technique</td>
<td>Adequate: The floss was threaded into the interproximal space; vertical (up and down) movements parallel to the tooth axis were made at least twice.</td>
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<tr>
<td></td>
<td>Inadequate: horizontal (sawing) movements, no movements (brief insertion into and immediately removal from the interproximal space).</td>
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2. Comparison between Neocone®, Alvogyl® and Zinc Oxide Eugenol Packing for the treatment of Dry Socket: A RCT


Alveolar osteitis (AO), more commonly referred to as “Dry Socket”, is a painful debilitating condition that occurs as a complication of tooth extraction in the permanent dentition. There appears to be no consensus on the criteria used to determine the diagnosis of AO and thus the wide range (1-30%) in the rate of incidence reported in published papers and reviews must be viewed with caution. Generally, though, the signs and symptoms usually occur 1-3 days following an extraction and include features such as postoperative pain (unrelieved by analgesics) in and around the extraction site, a partially or totally disintegrated blood clot within the alveolar socket, halitosis, necrotic debris, etc.1 Dry socket has a multifactorial etiology, which can be divided into general factors such as age, sex, decreased body resistance due to systemic disease, nutritional deficiency, etc., and local factors such as anatomical location, traumatic surgery, smoking, fibrinolysis of clot, local circulation, local anesthetics, and vasoconstrictors.1 Since dry socket is the most common post extraction complication, many researchers have attempted to find a successful method for its prevention. Systemic antibiotics, topical antibiotics, chlorhexidine, para-hydroxybenzoic acid, tranexamic acid, polylactic acid, steroids, eugenol containing dressings, lavage, 9-aminoacridine, etc., have been proposed to assist in the prevention of dry socket.1 However, this area remains controversial as no single method has gained universal acceptance.

The management of dry socket is as controversial as its aetiology and prevention. Different medicaments and carrier systems are commercially available with little scientific evidence to guide a selection process for their use. Faizel and colleagues (2015)5 reported on a trial that sought to assess the relative efficacy of different dressings for the management of pain and promotion of healing in AO.

MATERIALS AND METHODS

This study was conducted among patients who reported for dental extraction at the Department of Oral and Maxillofacial Surgery, Peoples College of Dental Sciences and Research Centre, Bhopal, India. Exclusion criteria included conditions such as pregnancy, history of radiotherapy, and coexisting cellulitis/fascial space infections.

Patients who reported with pain after tooth extraction were evaluated to ascertain the cause for this complaint. Diagnosis of AO was clinically established on the basis of the following features by a blinded assessor: (1) Pain in and around the extraction socket with or without radiation that increased in severity for some period from 1 and 3 days after extraction; (2) Partial or total clot loss in the interior of the alveolus with or without halitosis.

Any other associated findings such as halitosis, lymphadenopathy, etc., were also recorded. Patients were randomly assigned using a randomization table to one of the three groups A, B, and C in order to receive treatment for AO. Patients within these groups were managed as follows:

**Group A:** Alvogyl®. (Content—iodoform 15.8gm, eugenol B.P. 13.7gm, and butamben 25.7gm). A few fibers of Alvogyl® were placed with the help of a sterile instrument deep into the socket ensuring that the denuded bone was completely covered followed by the placement of sterile gauze. The gauze was removed after 5min.

**Group B:** Zinc Oxide Eugenol (ZOE). A piece of gauze soaked with freshly prepared ZOE paste was placed in the extraction socket under aseptic conditions.

**Group C:** Management of dry socket by Neocone®. (Content—polymyxine B sulfate, tyrothricin, neomycin sulfate, tetracaine hydrochloride). A single pellet of Neocone® was placed inside the socket followed by the placement of a piece of sterile gauze to cover the socket. The gauze was removed after 5 min.

The infected socket in all patients was irrigated with warm sterile saline solution. Curettage was avoided. Loose debris was removed, taking care to avoid dislodging any residual clot present in the socket.

The pain levels were assessed on the basis of Wong Baker Visual Analogue Scale after 5min, 30 min, 1h, day 1, day 2, day 3, day 5, day 7, and day 10 after placement of the medicament. The dressings were evaluated by a blinded assessor at every follow-up visit and were changed in case of persistence of pain. No further dressings were done if the patients had sustained pain relief for more than 48 h.

Clinical examinations for the signs of healing of dry socket were performed on 1st, 3rd, 5th, 7th, and 10th day by a blinded assessor. Persistence of parameters such as empty socket, bare bone, and erythema around the socket were noted after removal of the pack. For assessment of pain relief as well as healing, the patients were followed up on a daily basis if signs and symptoms persisted beyond 10 days.

RESULTS

A total of 7,106 teeth were extracted during the study period, of which 3,097 (43.59%) were extracted in males and 4,009 (56.41%) in females. 105 patients (1.64%) returned with signs and symptoms of dry socket in a total of 117 extractions. Of these, 69 (2.22%) dry sockets were noted in females and 48 (1.19%) dry sockets in males (male to female ratio was 1.86; P = 0.0008).

The patients in this series were divided into seven age groups. Mean age of the patients was 34.6 years. The highest incidence of dry socket was seen in the age group of 21–40 years; (P < 0.0001).

Pain was present in 117 (100%) cases, empty socket was present in 57 (48.71%), bare bone (partially denuded socket) was present in 53 (45.20%), halitosis in 61 (52.10%), and redness around socket was found in 45 (38.60%) cases. The time for onset of dry socket was calculated from the time lag between extraction and onset of pain. The analysis of data revealed that the largest number of cases [55 (47.10%)] had an onset on the third day after extraction. In 22 (18.80%) cases, symptoms manifested on the 2nd day, while 24 (20.51%) cases noted symptoms on the fourth day. Sixteen cases had an onset on the fifth day after extraction. Mean time for onset of the complication was 3.2 days. Teeth were
grouped into anatomical sites for the purpose of analysing dry socket distribution. Higher incidence of dry socket was found in the lower jaw (63.24%), as compared with the upper jaw (36.76%; \( P < 0.05 \)).

Highest incidence of dry socket in mandibular arch was seen in the third molar region (6.91%). The highest incidence in maxillary arch occurred in the second molar region (1.97%). It was observed that the incidence of dry socket in patients who underwent single tooth extraction was much higher than those who underwent multiple extractions (single extraction to multiple extraction ratio was 4.41:1 < \( P < 0.05 \)).

The incidence of dry socket was found to be higher in cases of trans-alveolar extraction than in intra-alveolar extraction (trans-alveolar extraction to intra-alveolar extraction ratio was 8.36:1 < \( P < 0.0001 \)).

When the reasons for extraction of teeth were analysed and correlated with incidence of dry socket, it was apparent that the highest incidence was noted in teeth which were extracted for recurrent pericoronitis (13.5%), while the lowest incidence was noted in patients who underwent prosthetic extractions (0.75%).

Of the 7,106 extractions, 1,020 were performed in patients with medical comorbidities including those on oral contraceptives and 6,086 extractions were performed in otherwise healthy individuals. The incidence of dry socket in the former set of patients was 57% (5.58%) higher than the latter 60% (0.98%). Among the patients with coexisting medically compromised states, higher incidence was noted in asthmatics (4/19 extractions), hypertensives (12/389 extractions), and those consuming oral contraceptive pills (14/110 extractions). These differences were again statistically significant.

A total of 1,085 teeth were extracted in smokers. The number of dry sockets in this subset was 30, an incidence of 2.76%. A total of 6,021 teeth were extracted in non-smokers. This subset had 87 dry sockets, an incidence of 1.44%. The difference was statistically significant (\( P = 0.02 \)).

Out of 7,106 teeth, 1,540 teeth were extracted in patients with good oral hygiene. The number of dry sockets in these patients was 9, an incidence of 0.58%. A total of 2,156 teeth were extracted in patients having fair oral hygiene; 31 dry sockets were encountered, an incidence of 1.43%. A total of 3,310 teeth were extracted in patients with poor oral hygiene. The incidence of dry socket was 2.32% (77 dry sockets).

The mean time to obtain initial pain relief with Alvogyl®, Neocone®, and ZOE were 7.35, 17.23, and 25.02 min respectively (i.e., Alvogyl® < Neocone® < ZOE pack). The difference in initial pain relief between all three groups was statistically significant (\( P < 0.0001 \)). Results suggest that Alvogyl® is superior to the other two medications for providing initial pain relief.

The mean times for complete pain relief with Alvogyl®, ZOE, and Neocone® were 6.47, 8.64, and 4.85 days, respectively (i.e., Neocone® < Alvogyl® < ZOE). The difference in complete pain relief between all three groups was statistically significant (\( P < 0.0001 \)).

The baseline clinical examination prior to initiation of treatment revealed severe pain in all patients (n=117; 100%). Other signs and symptoms included halitosis (n=61, 52.10%), empty socket, i.e., completely denuded socket (n=57, 47.50%), bare bone, i.e., partially denuded socket (n=53, 45.20%), and redness around socket (n=45, 38.60%).

Out of 117 sockets with AO, 53 presented with bare bone. Numbers of sockets treated for this sign with Alvogyl®, ZOE, and Neocone® were 19, 16, and 18, respectively. Of the 19 sockets treated with Alvogyl®, only ten (52.63%) still showed bare bone on the third day of follow up with 100% resolution on the tenth day of follow up. Of the 16 sockets treated with ZOE, twelve (75%) still exhibited bare bone on the third day of follow up with 100% resolution on the twelfth day of follow up. Of the 18 sockets treated with Neocone®, only seven (38.89%) were noted to have persistent bare bone on the third day of follow up, with 100% resolution on the fifth day of follow up. The resolution of this sign was fastest with Neocone® and slowest with ZOE.

Out of the 117 sockets with AO, 57 had redness around the socket. The numbers of sockets treated for this sign with Alvogyl®, ZOE, and Neocone® were 16, 14, and 15, respectively. Of the 16 sockets treated with Alvogyl®, ten (62.5%) continued to show redness around the socket on the third day with 100% resolution on the tenth day. Of the 14 sockets treated with ZOE, twelve (85.71%) still had persistent sign on the third day of follow up with 100% resolution on the tenth day. Of the 15 sockets treated with Neocone®, only seven (46.67%) had persistent redness around the socket on the third day of follow up. All three products had 100% resolution on the tenth day.

CONCLUSIONS

The authors concluded that:

- Neocone® emerged as the most suitable dressing material for the management of dry socket by virtue of shorter time required for complete pain relief, fewer visits for dressing change, and faster clinical healing of the socket. Onset of pain relief with Alvogyl® was faster but not sustained. ZOE was most cost-effective and easily available medicament for dressing. Intervention is preferably initiated immediately upon diagnosis. While all the three tested medicaments showed positive outcomes, Neocone® required the least replacement and was quicker in providing lasting pain relief. It may therefore be advantageous to use Neocone® dressings to facilitate faster recovery. To the patients, this may translate into earlier return to work and productivity.

- Alveolar osteitis is more likely in young adults, females, smokers, patients with medical co-morbidities, particularly asthmatics, and patients with poor oral hygiene and local infection such as pericoronitis. The likelihood is also higher in the mandibular molar region, particularly after trans-alveolar extractions and after singleton extraction rather than multiple. It is unclear whether these factors contribute to the risk independently or collectively.

Further studies are required to clarify this aspect in order to implement effective preventive strategy.

IMPLICATIONS FOR PRACTICE

Whilst Alvogyl® was found to be superior to the other two medicaments in providing initial pain relief, Neocone® clearly shows superior, longer lasting pain relief and healing potential as evidenced by improvement in clinical signs.

Reference

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GENERAL

Recent perspectives vis-a-vis the biological basis of tooth eruption (p238)
1. The dental follicle forms the periodontal ligament.
   a. True
   b. False

2. Tooth root formation and elongation is the sole mediator of tooth eruption
   a. True
   b. False

3. Receptor activator of nuclear factor kappa B ligand is a marker gene for osteoblastogenesis.
   a. True
   b. False

4. Which of the following is considered to be essential for eruption to take place?
   a. Dental follicle
   b. Root formation
   c. Epithelial root sheath
   d. Dental pulp

The effect of pre-etching of dentine, cut and uncut enamel on the shear bond strength (SBS) of silorane-based and methacrylate-based composite resin systems. (p 248)
5. ‘C-factor’ is defined as the ratio of bonded to unbonded areas within a restored cavity.
   a. True
   b. False

6. When the Silorane System Adhesive/Filtek Silorane (SSA/FS) system was used, pre-etching of all three tooth substrates (uncut and cut enamel for 20 seconds and dentine for 15 seconds) with 34 % phosphoric acid significantly improved SBS.
   a. True
   b. False

7. The mild Self-etch Adhesives systems do not bond as effectively to enamel as their total-etch counterparts.
   a. True
   b. False

8. When SSA and FS were used for bonding to tooth substrates that were not pre-etched, an adhesive fracture rate of 100% occurred.
   a. True
   b. False

Assessment of dose-width products of pre-programmed exposure technique parameters in panoramic dental radiology (p 242)
9. Standard reference measures are available for panoramic radiographic units.
   a. True
   b. False

10. The study showed that the exposure sequences of most panoramic units are well within recommended ALARA measures.
   a. True
   b. False

Perceived stress among dental students at the University of the Western Cape (p 255)
11. The key dimension of burnout in the Maslach Burn-out Inventory is:
   a. Personal achievement
   b. Emotional exhaustion
   c. De-personalisation
   d. Dental environment stress

12. Students rated lack of time for relaxation as a major stressor in the dental environment.
   a. True
   b. False

13. A high de-personalisation (DP) score is characterised by:
   a. emotional detachment from the needs of patients and peers.
   b. Over-involvement in the needs of the patient
   c. Instability in the class
   d. Overconfidence in dealing with chairside staff

A tongue ring barbell shank in the floor of the mouth: an incidental finding by panoramic and cephalometric radiographs— a case report and review of literature (p 260)
14. Piercing of the tongue is usually performed in the midline of the tongue anterior to lingual frenum.
   a. True
   b. False

Oral Medicine case book 71: Amyloidosis of the tongue (p 262)
15. Amyloidosis represents an intracellular deposition of abnormally folded fibrillary proteins.
   a. True
   b. False
16. Macroglosia and tongue crenations suggest amyloidosis
   a. True
   b. False

Maxillo-facial Radiology case book 133 (p 266)
17. Cleft lip and cleft palate are very infrequent congenital deformities.
   a. True
   b. False

Clinical Windows (p 267)
19. Winterfeld et al found that only about half the participants in the study actually flossed their teeth
   a. True
   b. False

20. Faizel et al found that the group treated with Neocone® recorded the shortest mean time in obtaining initial pain relief and that this was significantly better than the mean times associated with treatment by Alvogyl® or ZOE.
   a. True
   b. False

ETHICS
Ethical responsibilities when using locum tenens (p 264)
21. The benevolent and protective aspect of one’s duty to care both in terms of an expectation that one will always try for the best for the patient is related to the ethical principle of primum non nocere – ‘first do no harm’
   a. True
   b. False

22. The Ethical Rules of the Health Professions Act determine that a locum cannot be appointed for a period exceeding six months and that the locum must be registered as a health practitioner with the HPCSA.
   a. True
   b. False

23. ‘Vicarious liability’ is a doctrine of liability without fault, meaning one person is held liable to a third party for the unlawful act of another.
   a. True
   b. False

24. Locum tenens can be considered either as a ‘servant’ (employee) or as an ‘agent of the owner’ (independent contractor).
   a. True
   b. False

25. When a patient seeks care from a professional person, it would be a reasonable assumption for them to expect that the person was trained properly, appropriately skilled and competent to carry to deliver such care. This is often described as a ‘duty of care’.
   a. True
   b. False

Readers will note that we have reduced the number of General Questions to twenty whilst retaining five Ethics based questions. Our allocation of CPD points remains unchanged. There is optimism that this section will continue to provide members with a valuable source of CPD points whilst also achieving the objective of CPD, to assure Continuing Education.

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