Chiang Mai Dental Journal

Chiang Mai Dental Journal (ISSN 2773-921X) is an academic journal of the Faculty of Dentistry, Chiang Mai University that publishes academic articles and research papers about dentistry since 1977. Editors and experts in their respective fields review the articles received from authors. The content of all articles must be up-to-date, universal, logical, and according to academic principles so the reader can apply the knowledge and cite the work in the development of dentistry work, which will advance future research and be beneficial to patients and society.

At present, Chiang Mai Dental Journal openly receives all submissions through an online journal review process system. The new online system also allows reviewers and researchers an ability to read 3 issues each year

Aim and Scope of the journal

To compile research and content that is up to date and usable to all branches of dentistry and related fields. The articles in Chiang Mai Dental Journal are fundamental research work, including original articles, review articles, case reports/series, short communications, and letters to the editor.

Policy

Accepted articles will be fairly reviewed by the editors and experts with full transparency through the following process.

1. The articles must be correct according to academic principles and not duplicate works that have been previously published.
2. The articles will be considered and reviewed through a non-bias process by concealing the names of authors and related persons in the considered documents while also concealing the names of the experts and reviewers who review the articles (double-blind review).
3. The review process can be tracked online. The article authors can review the status of their article and are able to follow up on the article evaluation through the online process. The duration of each step is closely monitored so that the articles can be published on time.
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Chiang Mai Dental Journal invites the following submissions:

1. Original articles	Original contributions of research reports or unpublished recent academic research to the development and applications in dentistry and related fields. The original article must not exceed 4000 words in length and must contain no more than 10 figures and tables in total.
2. Review articles	Comprehensive reviews of special areas of focus in dentistry and related fields. Articles that contain important collected data from numerous books or journals and from the writer's experience. Information should be described, reviewed, compared, and analyzed. The review article must not exceed 4000 words in length and must contain no more than 10 figures and tables in total.
3. Systematic reviews	Clearly formulated reviews that uses systematic and reproducible methods to identify, select and critically appraise all relevant research, and to collect and analyze data from the studies that are included in the review.
4. Case reports/series	Original findings that highlight novel technical and/or clinical aspects in dentistry and related fields which include clinical symptoms, diagnosis, patient care, treatment, follow-up, and evaluation. The report must not exceed 2500 words in length and must contain no more than 5 figures.
5. Letters to the Editor	Commentaries on published papers in the journal and other relevant matters that must not exceed 1000 words in length
6. Short communications	Original contributions describing new developments of high impact that justify expedited review. The report must not exceed 2000 words in length and must contain no more than 3 figures.

Manuscript Preparation

All texts in the submitted manuscript are required to be inclusive language throughout that acknowledges diversity, conveys respect to all people, is sensitive to differences, and promotes equal opportunities. Authors should ensure that writing is free from bias, for instance by using 'he or she', 'his/her' instead of 'he' or 'his', and by making use of job titles that are free of stereotyping (for instance by using 'chairperson' instead of 'chairman' and 'flight attendant' instead of 'stewardess'). Articles should make no assumptions about the beliefs or commitments of any reader, should contain nothing which might imply that one individual is superior to another on the grounds of race, sex, religion, culture, or any other characteristic.

A. Title page (see 'Title page 'for an example)

The title page will remain separate from the manuscript throughout the peer review process and will not be sent to the reviewers. It should include these following details:

- Title should be concise, information-retrieval, and not exceed 30 words. Please avoid abbreviations and formulae where possible.
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Abstract must not exceed 250 words with concise and informative explanations about the article. Authors must prepare an abstract separately from the main manuscript using Microsoft Word processing software (.doc or .docx). Please avoid references and uncommon abbreviations, but if essential, abbreviations must be defined at their first mention in the abstract itself. Abstract structure of the original articles must consist of 'Objectives, Methods, Results, and Conclusions'.

Abstract of other types of submitted articles should be summarized in one paragraph. Up to five keywords relevant to the articles must be provided and arranged in alphabetical order.

C. Manuscript

Chiang Mai Dental Journal adheres to a double-blinded review. The main body of the paper (including the references, figures, tables and any acknowledgements) must not include any identifying information, such as the authors' names. The layout of the manuscript must be as simple as possible with double-spaced, single column format with Sans Serif font and uploaded as an editable Microsoft Word processing file (.doc or .docx). Complex codes or hyphenate options must be avoided, but the emphatic options such as bold face, italics, subscripts, and superscripts, etc. are encouraged.

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- *Introduction* should include literature reviews of previous studies, research questions, and the rationale for conducting the study. The Introduction should not be too long and should be easy to read and understand while avoiding a detailed literature survey or a summary of the results.
- *Methods* should provide sufficient details in a logical sequence to allow the work to be reproduced by an independent researcher. Methods that are already published should be summarized and indicated by a reference. If quoting directly from a previously published method, use quotation marks and cite the source. Any modifications to existing methods should also be described.
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- *Discussion* is criticism, explanation, and defense of the results from the standpoint of the author, and comparison with other peoples 'reports. The discussion can include criticism of materials, methods and study results, problems, and difficulties, pointing out the benefits of adoption and providing feedback where appropriate. Discussions should explore the significance of the results of the work, not repeat them. Avoid extensive citations and discussion of published literature.
- *Conclusions* refers to a summary of the study or research results.
- *Acknowledgments:* Please specify contributors to the article other than the authors accredited. Please also include specifications of the source of funding for the study.

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This work was supported by the 1st organization name [grant numbers xxxx]; the 2nd organization name [grant number yyyy]; and the 3rd organization name [grant number zzzz].

If no funding has been provided for the research, please include the following sentence:

This research did not receive any specific grant or funding from funding agencies in the public, commercial, or not-for-profit sectors.

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2. Review articles should be divided into Introduction, Review and Conclusions. The Introduction section should be focused to place the subject matter in context and to justify the need for the review. The Review section should be divided into logical sub-sections in order to improve readability and enhance understanding. Search strategies must be described, and the use of state-of-the-art evidence-based systematic approaches is expected. The use of tabulated and illustrative material is encouraged. The Conclusion section should reach clear conclusions and/or recommendations on the basis of the evidence presented.

3. Systematic review

- Introduction should be focused to place the subject matter in context and to justify the need for the review.
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- Results should present in structured fashion (e.g. results of the search process, characteristics of the included studies, results of primary meta-analysis, additional analysis, publication bias, quality of evidence).

- Discussion should summarize the results, highlighting completeness and applicability of evidence, quality of evidence, agreements and disagreements with other studies or reviews, strength and limitations, implications for practice and research.
- Conclusion(s) should reach clear conclusions and/or recommendations on the basis of the evidence presented.

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There are some necessary considerations which should be comprehended and consistent throughout the article:

1. Abbreviations: define abbreviations at their first occurrence in the article: in the abstract and in the main text after it. Please ensure consistency of abbreviations throughout the article.
2. Mathematical expressions: the numbers identifying mathematical expressions should be placed in parentheses after the equation, flush to the right margin; when referring to equations within text, use the following style: Eq. (5), Eqs. (3-10), [see Eq. (4)], etc.
3. Nomenclature: abbreviations and acronyms should be spelled out the first time they are used in the manuscript or spelled out in tables and figures (if necessary). Units of measure and time require no explanation. Dental nomenclature in the manuscript should be complete words, such as maxillary right central incisor. Numbering of teeth from pictures or tables should follow the FDI two-digit system.
4. Units: use the international system of units (SI). If other units are mentioned, please give their equivalent in SI.
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Any citations in the text should be placed in order and using numbers which are superscripted and put in parentheses. Please ensure that all citations are also present in the reference list consecutively in accordance with their appearance in the text.

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All references should be brought together at the end of the paper consecutively in accordance with their appearance in the text and should be in the Vancouver reference format. Please follow these examples of correct reference format below:

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1.1. One to six authors

Author(s) – Family name and initials. Title of article. Abbreviated journal title. Publication year;volume(issue):pages.

Example:

Parvez GM. Pharmacological activities of mango (Mangifera Indica): A review. J Pharmacognosy Phytother. 2016;5(3):1-7.

Or

Choi YS, Cho IH. An effect of immediate dentin sealing on the shear bond strength of resin cement to porcelain restoration. J Adv Prosthodont. 2010;2(2):39-45.

Or

Firmino RT, Ferreira FM, Martins CC, Granville-Garcia AF, Fraiz FC, Paiva SM. Is parental oral health literacy a predictor of children's oral health outcomes? Systematic review of the literature. Int J Paediatr Dent. 2018;28(5):459-71.

1.2. More than six authors

Author(s) – Family name and initials of the first six authors, et al. Title of article. Abbreviated journal title. Publication year;volume(issue):pages.

Example:

Vera J, Siqueira Jr JF, Ricucci D, Loghin S, Fernández N, Flores B, et al. One-versus two-visit endodontic treatment of teeth with apical periodontitis: a histobacteriologic study. J Endod. 2012;38(8):1040-52.

1.3. Article in press

Authors separated by commas – Family name and initials. Title of article. Abbreviated journal title in italics. Forthcoming - year of expected publication.

Example:

Cho HJ, Shin MS, Song Y, Park SK, Park SM, Kim HD. Severe periodontal disease increases acute myocardial infarction and stroke: a 10-year retrospective follow-up study. J Dent Res. Forthcoming 2021.

2. *Books*

2.1. Book with author (s)

Author(s) – Family name and initials (no more than 2 initials with no spaces between initials)– Multiple authors separated by a comma. After the 6th author add - "et al". Title of book. Edition of book if later than 1st ed. Place of publication: Publisher name; Year of publication.

Example:

Sherwood IA. Essentials of operative dentistry. Suffolk: Boydell & Brewer Ltd; 2010.

Or

Abrahams PH, Boon JM, Spratt JD. McMinn's clinical atlas of human anatomy. 6th edition. Amsterdam: Elsevier Health Sciences; 2008.

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Title of book. Edition of book if later than 1st ed. Place of publication: Publisher name; Year of publication.

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Example:

A guide for women with early breast cancer. Sydney: National Breast Cancer; 2003.

2.3. Chapter in a book

Author(s) of chapter - Family name and initials, Title of chapter. In: Editor(s) of book - Family name and initials, editors. Title of book. edition (if not first). Place of publication: Publisher name; Year of publication. p. [page numbers of chapter].

Example:

Rowlands TE, Haine LS. Acute limb ischaemia. In: Donnelly R, London NJM, editors. ABC of arterial and venous disease. 2nd ed. West Sussex: Blackwell Publishing; 2009. p. 123-140.

3. Thesis/dissertation

3.1. Thesis in print

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Example:

Kay JG. Intracellular cytokine trafficking and phagocytosis in macrophages [dissertation]. St Lucia, Qld: University of Queensland; 2007.

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Author - family named followed by initials. Thesis title [type of thesis/dissertation on the Internet]. Place of publication: Publisher; Year [cited date – year month day]. Available from: URL

Example:

Pahl KM. Preventing anxiety and promoting social and emotional strength in early childhood: an investigation of risk factors [dissertation on the Internet]. St Lucia, Qld: University of Queensland; 2009 [cited 2017 Nov 22]. Available from: https://espace.library.uq.edu.au/view/UQ:178027

4. *Webpage*

4.1. Webpage with author

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Example:

American Dental Association. COVID-19 and Oral Health Conditions [Internet]. Chicago: American Dental Association; 2021 Feb 12 [updated 2021 Feb 12; cited 2021 Jun 24]. Available from:https://www.ada.org/en/press-room/news-releases/2021-archives/february/covid-19-and-oral-health-conditions

4.2. Webpage with no authors

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Example:

Dentistry and ADHD [Internet]. 2019 Jan 15 [updated 2019 Jan 15; cited 2020 Apr 8]. Available from: https://snoozedentistry.net/blog/dentistry-and-adhd/

4.3. Image on a webpage

Author/organization. Title [image on the Internet]. Place of publication: Publisher's name; Publication date or year [updated date; cited date]. Available from: URL

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Example:

Poticny DJ. An Implant-Supported Denture Offers a Number of Advantages [image on the Internet]. Texas: Office of Dan Poticny; 2018 Nov 21 [updated 2018 Nov 21; cited 2019 Aug 30]. Available from: https://www.dfwsmiledoc.com/blog/post/an-implant-supported-denture-offers-a-number-of-advantages.html

5. *Government publications/reports*

5.1. Reports and other government publications

Author(s). Title of report. Place of publication: Publisher; Date of publication – year month (if applicable). Total number of pages (if applicable eg. 24 p.) Report No.: (if applicable)

Example:

Australian Institute of Health and Welfare. Oral health and dental care in Australia: key facts and figures trends 2014. Canberra: AIWH; 2014.

5.2. Government reports available online

Author(s). Title of report. Report No.: (if applicable). [Internet]. Place of publication: Publisher or Institution; Publication date or year [updated date - year month day; cited date - year month day]. Available from: URL

Example:

World Health Organization. WHO mortality database [Internet]. Geneva: World Health Organization; 2019 Dec 31 [updated 2019 Dec 31; cited 2021 Mar 29]. Available from: https://www.who.int/data/mortality/country-profile

6. *Tables/Figures/Appendices*

Follow the format of book, journal or website in which you found the table/figure/appendix followed by: table/figure/image/appendix number of original source, Title of table/figure/appendix from original source; p. Page number of table/figure/appendix from original source.

Note: each reference to a different table/figure within the same document requires a separate entry in the Reference list. Please provide permission documents from the original sources.

Example:

Smith J, Lipsitch M, Almond JW. Vaccine production, distribution, access, and uptake. Lancet 2011;378(9789):428-438. Table 1, Examples of vaccine classes and associated industrial challenges; p. 429.

7. *Journal abbreviation source*

Journal names should be abbreviated according to the Web of Science - Journal Title Abbreviations.

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Color Formation on Titanium Surface Treated by Anodization and the Surface Characteristics: A Review

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Abstract

Tooth loss is a common problem found in human beings. The challenge in replacing teeth is to restore the natural tooth appearance. Dental implants have overcome this challenge. Titanium (Ti) is an attractive material for dental implants due to its excellent properties and biocompatibility, but the grayish appearance is a concern. A process of supplying the current voltage to an electrochemical cell forming the oxide layer on metal is called anodization. Anodization is a surface modification technique that creates micro- and nano-roughness and an oxide layer on the Ti surface, improving the properties of dental implants. The higher the voltage applied to the anodizing process, the higher the anodic film thickness forms. The different thicknesses of titanium oxide (TiO_2) film cause variations in refractive index and reflective index, resulting in a desired color on the Ti surface. The most useful colors for dental application have been gold (10 V), yellow (60 to 65 V), and pink (70 to 80 V) in hue. Yellow and gold hues were mostly used in restoration or abutment areas while pink hue was used for gingival areas. The purposes of this literature review are to assess the current knowledge on the anodization process of titanium and its characteristics and to provide an overview of the literature on color formation on Ti surfaces by anodization.

Keywords: anodization, dental implant, titanium

Introduction

Since teeth are important organs for human beings, missing teeth can cause severe damage to other systems in the body in addition to affecting the quality of life as a role of esthetics, function, and speech.[1] Nowadays, replacing missing teeth is accomplished with either removable or fixed prostheses.

Dental implants are one of the treatment options that has become a standard in replacing teeth with a better outcome[1], wherein several materials have been used and developed for dental implants. Titanium (Ti) and its alloys are impressive because of their excellent biocompatibility, physical, mechanical, and chemical properties.[2] The excellent biocompatibility and long-term clinical survival rates of titanium have made this material the gold standard for dental implants.[3] Despite the material used, surface characteristics are another point of concern for good adaptation and biomechanical fixation.[4] Surface characteristics could be enhanced by several techniques of surface modification to provide micro- and nano-level roughness.[4]

Anodization or anodic oxidation technique is a great choice for surface modification as it provides a proper surface for osseointegration while being one of the techniques that produce an oxide layer on the Ti surface.[5-8] This can also overcome the disadvantage of titanium's grayish appearance by interference color from the oxide formation. The applied voltage has varied to form a thicker titanium oxide (TiO_2) layer, resulting in a more desired color on the Ti surface.[9,10]

The purposes of this literature review are to assess the current knowledge on the anodization process of Ti and its characteristics and to provide an overview of the literature on color formation on Ti surfaces by anodization.

Titanium in dentistry

An important consideration for dental implant success is a good adaptation between the implant surface and the surrounding tissue, both soft and hard.[11] Since the Brånemark discovery in the 1950s, the term "osseointegration" has described the direct contact between a loaded implant surface and bone at the microscopic level of resolution.[7,12,13]

For decades, Ti and Ti alloys have been considerably interesting in the dental field, especially in dental implants, because of their excellent biocompatibility, physical, mechanical, and chemical properties. Ti has compatibility with hard and soft tissues, non-cytotoxicity, excellent corrosion resistance, high strength, and low density.[2,9,14,15] Commercially pure titanium (cp-Ti) is classified into 4 grades according to its impurity content (grade 1-4: 0.18-0.4% Oxygen). Moreover, various alloys (e.g., Iron, Aluminum and Vanadium) have been added to cp-Ti to improve its mechanical properties: preventing corrosion, increasing its strength, and decreasing its density. Titanium-6aluminum-4vanadium (Ti-6Al-4V) alloys are the most common form of Ti alloys for dental use.[15-17]

The surface characteristics of Ti implants are one of the key factors that affect the rate of osseointegration and biological response, resulting in the success of implant placement.[18] Initially, the surface of the Ti implant is smooth, created by macroscale machining techniques. Subsequently, the surface roughness at both micro- and nano-level is more effective for osseointegration than smooth Ti, due to the improvement of protein adhesion and tissue integration.[19-21] The modifications on the implant surface have been developed in several techniques including grit-blasting, acid-etching, electrochemical anodic oxidation, plasma spraying, fluoride treatment, laser treatment, calcium-phosphate coatings, or several combinations of these techniques (e.g., combined sand-blasted, large-grit, acid-etched surface).[7,16,18,22]

Anodization / Anodic oxidation

Surface modifications by an electrochemical method called "Anodization/anodic oxidation" is interesting as it is a simple, inexpensive, and effective technique for improving surface properties.[7-9,23] TiO_2 layer, which is very thin (a few nm in thickness) and defective, is naturally formed when the Ti surface meets oxygen. This oxide layer is the true biocompatible surface on Ti dental implants. To enhance the oxide layer for suitable cellular activity on the Ti surface, the anodization process helps thicken and stabilize this layer, transforming it into a highly oriented structure. Accordingly, when the biocompatibility of the surface was increased, osseointegration was promoted.[5-8] This process can also affect the mechanical properties of the Ti dental implant in several ways, including changes in its corrosion resistance, surface roughness and wettability.[7,12,24]

The anodization process (Figure 1) involves using a power supply of constant current/voltage to an electrochemical cell with an electrolyte bath containing electrolytes that provide conduction (acid or basic solution). The common electrolytes are acids (e.g., sulfuric acid (H_2SO_4) and phosphoric acid (H_3PO_4)), and salts (e.g., sodium sulfate (Na_2SO_4), and ammonium sulfate $(NH_4)_2SO_4$).[9,12,19] The target substrate (Titanium) is on an anode, a positive electrical potential, while Platinum or Titanium is on the counter electrode (cathode). When the electricity runs, the oxygen is produced and combines with Ti on the Ti implant surface on the anode, forming the TiO_2 layer.[7,10,19,25]

The surface characteristics of anodized titanium

The surface characteristics of the anodized Ti surface are influenced by the anodizing conditions: the applied voltage, current density, anodization time, and types of electrolytes and concentration.[7,12] By increasing the voltage and current density, the thickness and resistance of the oxide layer are greater formed, resulting in increasing the surface porosity, thickness, roughness, wettability, and crystallinity. Likewise, extended anodization time brings a higher spark discharge intensity which induces the formation of a high surface area and high crystallinity anodic layer. For the type of electrolyte, the electrolyte could vary the pattern of microporous and crystallinity. Acidic electrolytes (sulfuric acid, acetic acid, phosphoric acid, and hydrochloric acid) and neutral electrolytes (sodium sulfate) form patterns of highly crystalline TiO_2 anodic layer while alkaline electrolyte (potassium hydroxide and sodium hydroxide) form patterns of nanoporous amorphous TiO_2 anodic layer. The electrolyte concentration also directly affects the surface porosity, thickness, roughness, and crystallinity.[7,12]

Cellular and tissue responses to the Ti surface have been widely investigated using fibroblasts, epithelial cells, and osteoblast-like cells.[2] Numerous *in vitro* cell culture experiments have shown that the anodized Ti surfaces expressed a positive effect on cell maturation and differentiation.[16] For hard tissue, Kim *et al.*[26] found that anodized Ti enhanced osteoblast adhesion and filopodia formation and has more mature bone formation than machined Ti, in addition to the bone implant contact (BIC) value being significantly greater. Furthermore, a study by Gulati *et al.*[27] on anodized 3D printed Ti implants showed that micro-scale and nano-topography from anodization provides an excellent cell adhesion substrate for human osteoblastic cells and promotes an osteogenic gene expression profile. These studies indicated that surface treatment by anodization increased osseointegration and bone formation. For soft tissue, Wang *et al.*[28] found that human gingival fibroblasts (HGFs) showed better adhesion strength, a more mature morphology, and greater proliferation and differentiation on rough Ti surfaces than on smooth surfaces. The filopodia of the HGFs on the surfaces of the anodized Ti were in contact with each other and formed a multidirectional net-

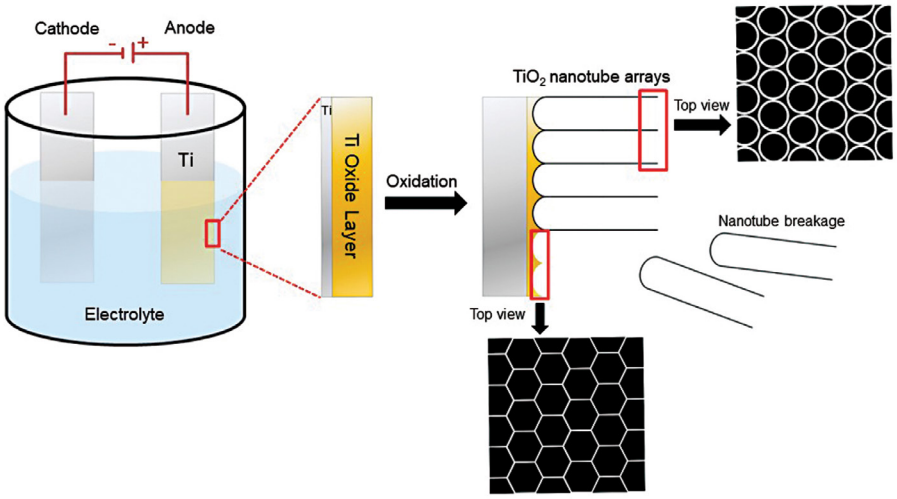

Figure 1: Schematic diagram showing the anodization process and the formation of TiO_2 nanotube arrays. The top view of the structures via scanning electron microscopy shows the circular forms of the tubules. The binding between the nanotube arrays and the Ti surface is generally weak, and breakdown is frequent at the interface. The morphology underneath the tubes is hexagonal. (Modified from Yeo *et al.*[7])

work while the HGFs on the untreated specimen aligned parallel to each other. On the other hand, a study by Fadeyev *et al.*[5] on the adhesion of fibroblasts on anodized Ti showed that the quantity and average area of fibroblasts adhered on nanotubular Ti was not significantly greater than on untreated Ti. However, the nanotubular surfaces from anodization did not cause excessive adhesion of fibroblasts that might lead to the risk of implant rejection from the formation of fibrous capsules.

The parameters that may promote implant-tissue interaction and osseointegration are surface roughness, surface composition, and wettability. There are three levels of surface roughness: macro-, micro-, and nano-scale topologies.[4] As nano-scale roughness and topography Ti surface are better at achieving desirable bonding with bone than the conventional smooth or micro-rough surfaces, the electrochemical anodization helps fabricate the ordered nanostructures with suitable physicochemical properties, especially titania nanotubes.[20,24,27] Yao *et al.*[29] varied the anodization conditions and found that the resulting anodized titanium surface on SEM and AFM can either be heterogeneous nanoparticles (inner diameter sized about 30-40 nm) or ordered nanotube-like structure (inner diameter sized about 70-80 nm). Villaça-Carvalho *et al.*[8] found that the anodized Ti showed changes in the chemical and structural composition of the TiO_2 film, favorable to osteogenic activity. From SEM analysis, a nanotextured surface was also observed with topography more uniform and valleys less depth (Figure 1). The aligned TiO_2 nanotube-layered surface has great potential in biological and clinical applications.[7] Moreover, it seems to be contradictory on the optimal diameter for osseointegration as there were four different stages according to Wu *et al.*[30], including protein absorption, inflammatory cell adhesion/inflammatory response, additional relevant cells adhesion, and angiogenesis/osteogenesis. They believed that TiO_2 nanotubes of about 30 nm diameter are more suitable for the function of relevant protein absorption, TiO_2 nanotubes of about 15 nm diameter are more suitable for inflammatory regulation, TiO_2 nanotubes of 15-30 nm diameter have a positive effect on repairment-related cell adhesion, and TiO_2 nanotubes of about 100 nm diameter are suitable for osteogenesis.[30] However, several studies confirmed that the optimal diameter of TiO_2 nanotubes for osteoblasts functions on titania is less than 100 nm.[24,29]

The wettability (hydrophilicity and hydrophobicity) or water contact angle, which is affected by surface composition, plays an important role in the cell response. Biological fluids, cells, and tissues prefer highly hydrophilic surfaces (lower water contact angle). Since the anodization process changed the amorphous TiO_2 nanotubes into a crystalline form, the surface became more hydrophilic, resulting in the proper environment for cell behavior.[4,24,28] Wu *et al.*[30] suggested that it is hard to conclude precisely the best degree of contact angle for protein absorption but the contact angle of TiO_2 nanotubes below 50 degrees shows better biological activity compared with materials with larger contact angle.

Although the mechanical properties change to promote implant-tissue interaction and osseointegration, the anodized Ti may appear in different colors due to the thickness and crystal structure of the TiO_2 layers.[12] The color formation helps improve the reflection of the underlying metal surface, which produced a gray metal color when white light is emitted on the unanodized Ti.[10]

Color formation on titanium surface by anodization

One of the disadvantages of using Ti as a dental implant abutment is the grayish appearance (the metallic gray color) that affects the peri-implant soft tissue, especially in high esthetic areas (anterior maxilla area) or when some unfavorable soft tissue conditions (thin peri-implant mucosa or recession) are present.[31] This grayish appearance is caused by the reflection of white light on the TiO_2 layer of the metal surface.

The TiO_2 layer, a clear and thin (approximately 5-20 nm in dimension) layer, is produced when Ti or Ti alloys make contact with the oxygen in the air.[10] However, the anodization helps increase the thickness of the oxide layer up to about 100 nm[16], with greater thickness when higher voltage is applied. The higher the voltage, the higher the anodic film thickness forms. The different thicknesses of TiO_2 cause variations in refractive index and reflective index which produces various colors of anodized Ti. The color-producing phenomenon on the Ti surface after anodizing is known as interference colors (light interference effects produce a color change) (Figure 2), which may be useful in prosthetic dentistry.[9,10]

The color formation of anodized Ti can be explained by the multi-beam interference theory (Figure 2). The reflected beams from the TiO_2 surface and the

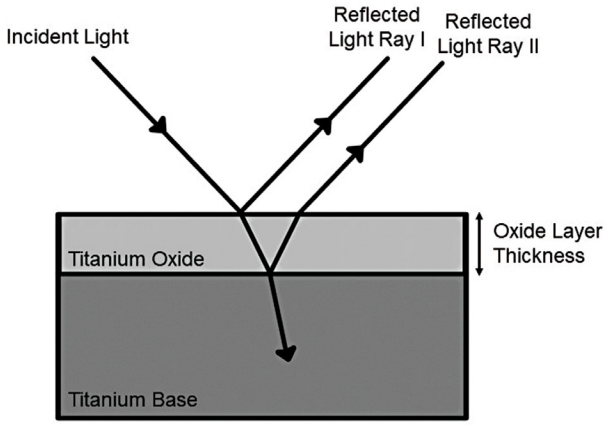

Figure 2: Multi-beam interference theory for color formation on anodized titanium. (Modified from Alipal *et al.*[12], Diamanti *et al.*[14])

surface between TiO_2 and Ti base can produce interference colors. The color will change depending on the increase in oxide thickness and the crystalline structures in the oxide layer. The constructive and destructive interference of certain wavelengths results in various colors.[12]

To obtain the desired color on the Ti surface, the feeding voltage (V) is applied during the anodizing process. This technique provides a straightforward means of coating Ti parts and a color scale. Karambakhsh *et al.*[32] anodized pure commercial Ti surface in sulfuric acid from 5 V to 80 V. The colors produced were gold/brown (5, 10 V), violet (15 V), dark blue (20 V), blue (25, 30 V), green/blue (35 V), light blue (40 V), pale blue (45 V), dark yellow (50 V), yellow (55, 60 V), pink/yellow (70 V), pink (75 V) and pink/purple (80 V) as shown in Table 1. Wadhwani *et al.*[33] altered the abutment color by anodization in a laboratory using trisodium phosphate as an electrolyte. The voltage of 60 V and 85 V were used to achieve yellow and pink colors, respectively. Napoli *et al.*[25] applied electrolytic voltage ranging from 15 V to 150 V on grade II Ti and grade V Ti in a citric acid electrolyte bath, which produced a wide gamma of colors, where brown/yellow (17 V), blue/light blue (30, 40, 60 V), gold (80, 100 V), and fuchsia/purple (150 V) were the colors achieved from the growing potential in this experiment. Wadhwani *et al.*[10] varied the voltage of anodization from 0 V to 85 V on titanium-6aluminum-4vanadium (Ti-6Al-4V) alloy using trisodium phosphate as an electrolyte, resulting in the variation of oxide film thickness and coloration. The resulting colors were gold (10 V), brown (15 V), purple (20 V), dark blue (25 V), light blues (30, 35, 40 V), pale blue (45 V), white/yellow (50, 55 V), yellow (60, 65 V), pink/yellow (70 V), pink (75, 80 V) and pink/purple (85 V). Similarly, Wang *et al.*[28] also produced a variety of colors on the surfaces of Ti alloys by anodization at 5 V to 90 V in phosphoric acid. The colors changed synchronously with the alteration of anodization voltages as gold/brown (5, 10 V), brown (15 V), violet (20 V), dark blue (25 V), blue (30 V), light blue (35 V), green/blue (40, 45 V), light green (50 V), green/yellow (55 V), yellow/orange (60 V), red/pink (65 V), pink (70 V), purple (75 V), purple/blue (80 V), blue (85 V) and green (90 V).

The hue, chroma, and value of color varied in the same pattern as shown in Table 1. This color and brightness changes through anodization only modified the surface of the Ti by altering the TiO_2 layer thickness, yet the surface chemistry, tensile, and other mechanical properties of the materials remained the same. The surface biocompatibility is still maintained as well. Additionally, anodization is a reversible process, where the oxide layer on the Ti surface can simply be removed and returned to its clear state if any error has occurred or the color is not as desired.[10,33]

The spectrophotometer and the CIELab color space (Standard colorimetric space) (Figure 3) play a role in measuring the color change from anodization, hue (type of color), chroma (saturation), and value (lightness). CIELab has a three-dimensional color space: L* (luminosity; black [0] – white [100]), a* (green [-] – red [+]), and b* (blue [-] – yellow [+]) value.[25,28,32] A change in applied voltage causes changes in oxide film thickness, resulting in the variations of the refractive and reflective index on the color of anodized Ti. The CIELab color can be used to compare the different color ranges and the mean color difference (ΔE) can also be calculated using the CIE parameter. From the study by Napoli *et al.*[25] in grade II Ti and grade V (Ti-6Al-4V) Ti, by using CIELab color space, there are no differences in color produced between pure Ti and Ti alloy as they both showed an excellent uniformity of color from a macroscopic point of view. This can be concluded that the anodization can vary color in the same direction even with the use of different grades of Ti.

Table 1: The color formation on titanium surface at different voltages applied in the anodization process from previous studies. (Modified from Wadhwani *et al.*[10], Napoli *et al.*[25], Wang *et al.*[28], Karambakhsh *et al.*[32], Wadhwani *et al.*[33])

Year	Writer	Article	Anodized condition	Voltage applied (V)																				
				0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	100	150
2011	Karambakhsh *et al.*[32]	Pure commercial titanium color anodizing and corrosion resistance	Pure commercial titanium Electrolyte: Sulfuric acid Voltage: 5-80 V Time: 30 sec	X																	X	X	X	X
2016	Wadhwani *et al.*[10]	Laboratory technique for coloring titanium abutments to improve esthetics	Titanium-based abutment Electrolyte: Trisodium phosphate solution Voltage: 60 and 85 V Time: 5 sec	C	X	X	X	X	X	X	X	X	X	X	X		X	X	X	X		X	X	X
2018	Napoli *et al.*[25]	Coloring titanium alloy by anodic oxidation	Type II titanium Electrolyte: Citric acid Voltage: 15-150 V	X	X	X		X	X		X		X	X	X		X	X	X		X	X		
			Type V titanium Electrolyte: Citric acid Voltage: 15-150 V	X	X	X		X	X		X		X	X	X		X	X	X		X	X		
2018	Wadhwani *et al.*[10]	Colorizing titanium-6alumi-num-4vanadium alloy using electrochemical anodization: Developing a color chart	Titanium alloy (Ti6Al4V) Electrolyte: Trisodium phosphate solution Voltage: 0-85 V Time: 15 sec	C	X																	X	X	X
2018	Wang *et al.*[28]	Changes in the esthetics, physical, and biological properties of a titanium alloy abutment treated by anodic oxidation	Titanium alloy (Ti6Al4V) Electrolyte: Phosphoric acid Voltage: 0-90 V Time: 60 sec	X																			X	X

C = Control, (17) = Voltage applied 17 V

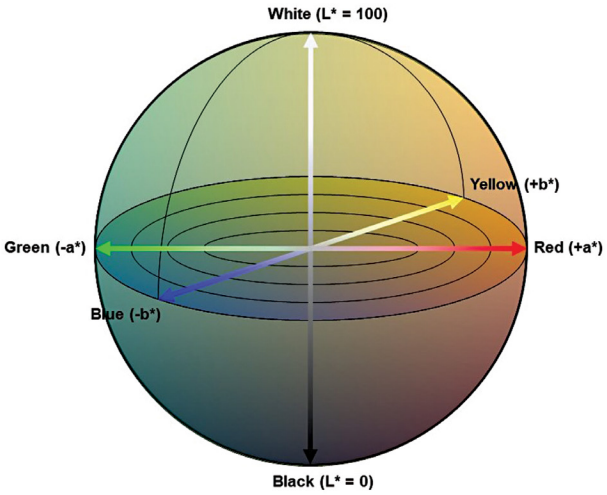

Figure 3: 3D CIELab color space. (Modified from Napoli *et al.*[25], Karambakhsh *et al.*[32])

Clinical application of anodized colored titanium

The preservation or reproduction of a natural mucogingival architecture surrounding dental implants is challenging from an esthetic viewpoint.[34] When the anodized titanium abutment was placed in the high esthetic area, it seems to have a more beneficial outcome over an unanodized Ti abutment on the color change of peri-implant soft tissue surrounding a Ti abutment.[26,31] (Figure 4) This could also reduce the risk of advanced surgery such as tissue augmentation and grafting in compromised cases.[31]

The most useful colors for dental application are gold (10 V), yellow (60 to 65 V), and pink (70 to 80 V) in hue.[10,35] Yellow and gold hues have mostly been used in restoration or abutment areas while pink hue has been used for gingival areas.[33,36] Similarly, several studies on the effects of implant abutment material on peri-implant soft tissue color have concluded that the peri-implant soft tissue color appears to be different from the soft tissue color around natural teeth.[34] Ti abutment has a significantly high color difference[34] wherein gold-anodized and pink-anodized Ti abutments have achieved better esthetics for peri-implant soft tissue than the unanodized Ti abutment.[36-39] Furthermore, zirconia abutments have resulted in the least color difference.[34,37-39]

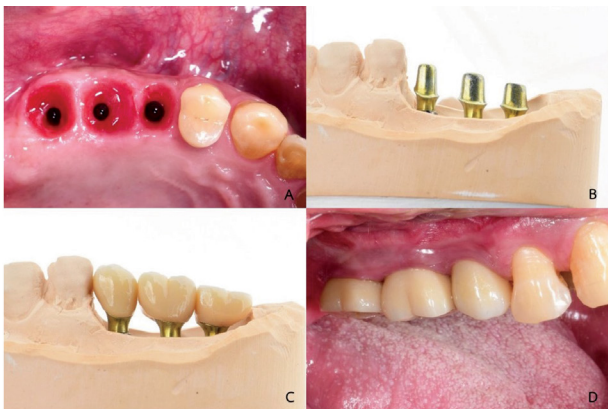

Figure 4: Displays a gold-anodized titanium implant placement. A–Soft tissue before gold-anodized titanium abutment in place, B–Laboratory gold-anodized titanium abutment, C–Laboratory gold-anodized titanium abutment with crown, D–Gold-anodized titanium implant in place. (Photo by Tachakorn Kuntiyaratana)

Besides analyzing the color differences, the pink esthetic score (PES), clinician and patient satisfaction questionnaires were measured where no significant difference was found in patient or clinician perception/satisfaction between gold/pink-anodized abutment, and zirconia abutment materials.[37,39] Patients were significantly more satisfied than clinicians with gingival esthetics surrounding the implant restoration.[37] However, pink-anodized abutments represent a good esthetic alternative to zirconia hybrid abutments, especially in mechanically challenging situations.[39] Although there was no significant difference in the soft tissue response between the zirconia and Ti abutments, the mechanical properties of zirconia are inferior to that of Ti.[15]

The selection of a dental implant system that allows a proper biological response of the hard and soft tissues, represents the first step for the achievement of adequate esthetic results. A proper surgical technique, implant positioning, and soft tissue management, along with the proper prosthetic solution are also necessary for a natural outcome.[34] Anodized Ti has achieved a good esthetic outcome. However, the color formation of the TiO_2 layer is not the only factor in successful implant placement in high esthetic areas. Other surface characteristics and properties of the Ti should also be considered simultaneously.

Conclusions

Anodization is a productive electrochemical method to modify the oxide layer on the Ti surface. Despite the micro- and nano-level roughness of the surface, the interference color from the oxide formation is an advantage that helps overcome the grayish appearance of Ti resulting

in a good esthetic outcome. It is a voltage-dependent process that can produce and reproduce a desired color. Pink- and gold-anodized Ti represent a good esthetic alternative to other abutments, especially in mechanically challenging situations. This paper reviewed the surface characteristics of anodized Ti and the color formation on Ti surfaces by anodization. Besides esthetic concern, the most important consideration for dental implant success is a good adaptation between the implant surface and the surrounding tissue, therefore the relationship between each color produced and surface characteristics requires further study.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Factors Affecting Stress and Stress Management Among Dentists Graduated from Chiang Mai University

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Abstract

Objectives: This study aims to explore the levels of overall and occupational stress, correlation between overall and occupational stress, factors affecting overall and occupational stress, and stress management strategies among dentists who graduated from Chiang Mai University.

Methods: 2,650 dentists who graduated from Chiang Mai University between 1983 and 2020 and are now working in Thailand were the subject of this study. Between May and September 2021, 2,466 dentists were provided online surveys that included the Suanprung Stress Test-20, Work Stress Inventory for Dentists, and Stress-coping strategy checklist. 588 respondents filled out the surveys (response rate was 23.8%). With the level of significance set at 0.05, descriptive and analytical statistics were used to examine the data using SPSS.

Results: 78% of respondents had moderate to high level of overall stress, 84.9% had low to normal level of occupational stress. There was a positive correlation between overall and occupational stress (rs=0.686, $p<0.001$). 'age', 'having underlying disease', and 'financial status' were the factors which significantly resulted in different overall stress scores ($p<0.05$). 'hobbies' had the highest rating for stress coping (87.6%), followed by 'resting' (79.7%) and 'eating' (68.4%).

Conclusions: The majority of dentists had normal levels of occupational stress, moderate to high levels of overall stress, and occupational stress significantly correlated with overall stress. There were a few factors that affect overall stress after adjusting for influences of the confounding variables. And there were a variety of stress coping strategies that dentists used for stress management. The findings of this study could be useful for strategic planning to prevent and resolve dentists' stress issues in the future.

Keywords: Chiang Mai University, dentist, factors, management, stress

Introduction

It is recognized that dentistry is a stressful profession.[1-3] There are numerous sources of stress for dentists, including the necessity for high-quality work, working in confined spaces, requiring intense focus, using coordinated movements of various body parts, frequently having to stay in one position for extended periods of time,[4] treating a high volume of patients on a time limit, attempts to establish a practice and dealing with different patients (especially nervous or high-expectation patients), and the development of new and complex technologies, methods and treatment techniques.[5,6]

Prolonged exposure to these stressors results in dentists tending to experience chronic high levels of occupational stress, which may have an impact on physical health, mental health, and health behaviors. The most commonly reported stress-related physical health issues are lower back pain, musculoskeletal pain, headache, and gastrointestinal problems.[6] Moreover, dentists also reported having a significantly high risk of coronary heart disease and immune disease due to occupational stress more than general population.[7] Regarding mental health, the consequences often include burnout, anxiety, and depression,[1] which can decrease motivation and self-esteem.[6] Additionally, stress experienced by dentists can even lead to suicide; the risk among dentists is higher than in the rest of the general population.[8] As for health behaviors, dentists are at a higher risk for stress exhibit poorer health and a higher rate of unhealthy behaviors than their less stressed colleagues.[6] The study found that 12-19% of dentists and physicians become addicted to alcohol or drugs, while in the general American population that figure is only 10-12%.[9] In short, a chronic high level of occupational stress can have manifold negative effects on dentists' health and wellbeing. It can also have negative effects on their interpersonal and professional relationships due to poor work quality, poor communication, and poor management.[3]

Numerous factors can induce stress in dentists, including work-related stressors, dentist–patient interactions, and dentist personality traits and perceptions of stress.[9] Regulations, dental healthcare systems, workplace culture, work sector, quality of the work environment, lack of material resources, understaffing, and poor staff quality are additional factors that can contribute to stress.[10] Dentists with identical stressors will experience disparate levels of stress and choose distinct coping methods due to individual differences in the factors mentioned above. Therefore, it is important that dentists recognize their stressors and regularly measure their stress levels to prevent or minimize the negative effects that stress may have on their physical and mental well-being, as the ability of dentists to maintain balanced stress levels and engage in effective coping strategies may impact their overall health.[6,9]

Based on the significance of the issues caused by occupational stress described above, we recognized the significance of stress issues in dentists' professional and personal lives and its consequences. From literature review, there were several studies about stress among dentists in Thailand, with publication years of 1987, 2007, and 2008.[11-13] As a result, a current study on stress among dentists who graduated from Chiang Mai University in 2021 was carried out, with the aim to explore the levels of overall and occupational stress, correlation between overall and occupational stress, factors affecting overall and occupational stress, and their stress management. The findings of this study could be used for strategic planning to prevent and resolve dentists' stress issues. Without a suitable solution and management, the stress issue will affect not only the dentists but also adjacent residents and patients.

Materials and Methods

Subjects

2,650 dentists who graduated from Chiang Mai University between 1983 and 2020 and are now working in Thailand were included in the study (receiving data from Dentistry CMU Alumni Association, April 2021).

Ethical considerations

The study was approved by the Research Ethic Committee Faculty of Public Health, Chiang Mai University (ET011/2564) on April 26th, 2021. The study details were explained to all subjects and informed consent was obtained by click agree before participation.

Questionnaire construction

The Google form questionnaire was divided into six parts:

1. Three-question quiz to ensure the respondent was

a dentist

2. Demographic information as gender, age, marital status, etc.

3. Work-related information as sector of practice, location of practice, years of practice, etc.

4. Suanprung Stress Test-20 (SPST-20)[14]: Participants were asked 20 questions to rate the level of stress they experienced over the last six months on a five-point scale ranging from '1=No stress' to '5=A great deal of stress'. The total score will be used to define four levels of stress, ranging from mild to severe.

5. Work Stress Inventory for Dentists (WSID): This was developed from the original version by Cooper *et al.*[5] and Choy and Wong[15] to identify specific work stressors experienced by general dental practitioners. Participants were asked to rate the level of stress they experienced on a five-point scale ranging from '1=No stress' to '5=A great deal of stress'. Twenty-seven stressors were grouped into five domains: patient-related, time-related, income-related, job-related, and staff-related or technically related.

6. Stress-coping strategy checklist: This was developed from our literature review.[2,6,15,16] There were 14 activities in this part, and participants were given the option to select the choices that best described their strategies for stress management.

In Thailand, the Suanprung Stress Test-20 (SPST-20), which showed concurrent validity >0.27 and a Cronbach's alpha of >0.7, was widely employed to measure overall stress. The study did not modify any of the material and utilized SPST-20 to measure subjects' overall stress. The Work Stress Inventory for Dentists (WSID) and the Stress-coping strategy checklist were used in a reliability test with a Cronbach's reliability coefficient alpha=0.9 and previous content validity from 3 quality test experts.

Data collection

After receiving contact information from Dentistry CMU Alumni Association, the questionnaires were sent to the 2,466 dentists who graduated from Chiang Mai University and are working in Thailand via social media (Facebook messenger, LINE messenger, etc.), e-mail, and post mail between May and September 2021.

Statistical analysis

The data were analyzed using the SPSS (Windows version 18). Descriptive statistics were described as frequencies, percentages, means, and standard deviations. Analytic statistics used Spearman's Rank Correlation, Mann-Whitney U test, Kruskal-Wallis H test, and Linear regression, with the level of significance at 0.05.

Results

Response

184 of the 2,650 dentists could not be contacted; questionnaires were sent to the remaining 2,466 dentists. 588 questionnaires were returned (a response rate of 23.8%). There were 12 incomplete questionnaires, and 576 complete questionnaires were brought in for analysis.

Demographic information

Of the 576 respondents, 67.2% (n=387) were female. Most participants were between the ages of 30 and 39 (34.4%, n=198), 79.5% (n=458) had no underlying disease, 44.4% (n=256) reported exercising once or twice a week, 59.5% (n=343) claimed to be single, 28.1% (n=162) reported having an income 70,001-100,000 Baht per month, 46.8% (n=270) reported having one or more people in their care, 49.8% (n=287) had income greater than to expense 0 to 50%, 53.0% (n=305) were general practitioners, 70.3% (n=405) worked in the public sector, 51.4% (n=296) did not work at their hometown, 31.4% (n=181) had 5-9 years of work experience, 80.6% (n=464) provided dental services, 36.5% (n=210) worked 35.1-42 hours per week, and 78.0% (n=449) did not own a dental clinic (Table 2).

Overall stress and occupational stress

The mean (± standard deviation) total SPST score was 45.48±17.16, which indicated that dentists had high level of stress. The mean (± standard deviation) total WSID score was 74.58±18.6. As shown in Table 1, the SPST and WSID scores were divided into a variety of stress levels.

As compared to all respondents, there were different proportions in some variables for 321 respondents in the group with a high to severe level of SPST scores and 87 in the group with a high to severe level of WSID scores as shown in Table 2.

Table 3 shows the mean for each of the five domains of occupational stressors. The patient-related stressors group had the highest mean score (3.61±0.67), while job-related stressors group had the lowest mean score (1.92±0.75).

The top 10 stressors according to the percentage distribution of the respondents' ratings '4' or '5' (considered to be high level) are shown in Table 4. Five of the top 10 highest ranked stressors were patient-related stressors. The 6th-10th were time-related stressors and staff-related or technically related stressors.

The relationship between SPST scores and WSID scores

SPST scores were significantly highly correlated with WSID scores (r_s=0.686, p<0.001). In addition, SPST scores were also significantly highly correlated with all five domains of occupational stressors: patient-related (r_s=0.422, p<0.001), time-related (r_s=0.558, p<0.001), income-related (r_s=0.556, p<0.001), job-related (r_s=0.581, p<0.001), and staff-related or technically-related (r_s=0.561, p<0.001). This means that high overall stress was associated with high perception of occupational stressors (considered to be high occupational stress).

Differences in overall stress and occupational stress according to demographic and work-related information

Numerous factors significantly affected both overall stress and occupational stress (p<0.05), including age, marital status, income per month, financial status, graduate qualifications, location of practice, years of practice, and ownership of dental clinic. Several factors significantly affected overall stress only, including having underlying disease, exercise frequency, and sector of practice (Table 5). Therefore, the factors that significantly affected occupational stress were a subset of the factors that significantly affected overall stress.

Regression analysis of factors to adjusting for influences of the confounding variables

After adjusting for influences of the confounding variables, age, having an underlying disease, and financial status were the factors that significantly affected overall stress scores (p<0.05), while none of the factors significantly affected occupational stress scores, as shown in Table 6.

Effects of age and other factors on overall stress scores

The results showed stress scores vary among age groups. Dentists over 40 years old reported less stress than other age groups. Dentists with underlying diseases, with income equal to expenses, or who worked in the public sector reported more stress than others in every age group. Divorced and bereaved status induced high stress in dentists in 30-39 years old group and divorced status induced high stress in dentists over 40 years old group. Participation in further coursework after graduation from dental school induced low stress among dentists in the 20-29 years old group. Working in non–hometown cities induced high stress in dentists in 20-29 years old group. And owning a dental clinic could induce or reduce stress based on age group.

Table 1: Number and percentage of respondents group by level of overall stress and occupational stress

Level of overall stress	Number (percentage) of respondents	Level of occupational stress	Number (percentage) of respondents
mild stress[1]	49(8.5)	normal stress [a]	254(44.1)
moderate stress[2]	206(35.8)	low stress [b]	235(40.8)
high stress[3]	213(37.0)	high stress [c]	85(14.8)
severe stress[4]	108(18.7)	severe stress [d]	2(0.3)
Total	576(100.0)	Total	576(100.0)

[1] had SPST scores 0-23, [2] had SPST scores 24-41, [3] had SPST scores 42-61, and [4] had SPST scores more than 61, [a] had WSID score ≤ mean, [b] had WSID score between mean and mean + SD, [c] had WSID score from mean + SD to mean + 2SD, and [d] had WSID score mean + 2SD and above

Table 2: Number and percentage of respondents group by personal and work-related factors compared between high to severe level of SPST scores and high to severe level of WSID scores

Demographics	Number (percentage) of respondents		
	Overall (n=576)	High to severe level of SPST scores (n=321)	High to severe level of WSID scores (n=87)
Personal factors			
1. Gender			
Male	189(32.8)	106(33.0)	27(31.0)
Female	387(67.2)	215(67.0)	60(69.0)
2. Age (years)			
20-29	152(26.4)	113(35.2)	32(36.8)
30-39	198(34.4)	118(36.8)	29(33.3)
40-49	123(21.3)	51(15.9)	15(17.3)
≥50	103(17.9)	39(12.1)	11(12.6)
3. Having underlying disease			
Yes	118(20.5)	78(24.3)	19(21.8)
No	458(79.5)	243(75.7)	68(78.2)
4. Exercise frequency			
No exercise	126(21.9)	78(24.3)	25(28.7)
1-2 times/week	256(44.4)	148(46.1)	35(40.2)
≥3 times/week	194(33.7)	95(29.6)	27(31.1)
5. Marital status			
Single	343(59.5)	210(65.4)	62(71.3)
No single but unmarried	25(4.4)	18(5.6)	1(1.1)
Married	200(34.7)	88(27.4)	22(25.3)
Divorced	4(0.7)	4(1.3)	2(2.3)
Bereaved	4(0.7)	1(0.3)	0(0.0)
6. Income per month (Baht)			
≤30,000	16(2.8)	11(3.4)	4(4.6)
30,001-50,000	119(20.7)	80(24.9)	22(25.3)
50,001-70,000	137(23.8)	87(27.2)	27(31.0)
70,001-100,000	162(28.1)	73(22.7)	18(20.7)
> 100,000	142(24.6)	70(21.8)	16(18.4)
7. Number of persons under care			
None	183(31.8)	102(31.8)	32(36.8)
1-2	270(46.8)	155(48.3)	37(42.5)
3-4	101(17.6)	50(15.5)	13(15.0)
>4	22(3.8)	14(4.4)	5(5.7)
8. Financial status			
Income > Expense (≥50%)	200(34.7)	90(28.0)	25(28.7)
Income > Expense (<50%)	287(49.8)	168(52.4)	47(54.1)
Income = Expense	69(12.0)	48(14.9)	13(14.9)
Income < Expense (<50%)	14(2.5)	12(3.8)	2(2.3)
Income < Expense (≥50%)	6(1.0)	3(0.9)	0(0.0)
9. Graduate qualifications			
General practitioner	305(53.0)	189(58.9)	61(70.1)
Postgraduate	92(15.9)	53(16.5)	11(12.7)
M.D./Ph.D.	108(18.8)	46(14.3)	5(5.7)
Resident	71(12.3)	33(10.3)	10(11.5)
Work-related factors			
10. Sector of practice	405(70.3)	240(74.8)	69(79.3)
Public	171(29.7)	81(25.2)	18(20.7)
Private			

11. Location of practice (work at hometown)			
Yes	280(48.6)	138(43.0)	44(50.6)
No	296(51.4)	183(57.0)	43(49.4)
12. Years of practice			
<5	114(19.8)	81(25.2)	24(27.6)
5-9	181(31.4)	124(38.7)	30(34.5)
10-19	106(18.4)	43(13.4)	13(14.9)
≥20	175(30.4)	73(22.7)	20(23.0)
13. Type of practice			
Dental Practitioner	464(80.6)	264(82.2)	72(82.8)
Teacher	55(9.5)	30(9.4)	6(6.9)
Dental Public Health Administrator	38(6.6)	16(5.0)	6(6.9)
Public Health Administrator	13(2.3)	8(2.5)	2(2.3)
Researcher	4(0.7)	3(0.9)	1(1.1)
Others	2(0.3)	0(0.0)	0(0.0)
14. Hours of working per week			
≤35	184(31.9)	102(31.8)	26(29.9)
35.1-42	210(36.5)	121(37.7)	35(40.2)
≥42	182(31.6)	98(30.5)	26(29.9)
15. Ownership of dental clinic	127(22.0)	57(17.8)	12(13.8)
Yes	449(78.0)	264(82.2)	75(86.2)
No			

Table 3: Average mean for each domain.

Occupational stressors: Five domains	WSID score ($\bar{x}$±SD)
1. Patient-related stressors	3.61±0.67
2. Time-related stressors	3.12±0.82
3. Staff-related or technically related stressors	2.83±0.73
4. Income-related stressors	2.59±0.88
5. Job- related stressors	1.92±0.75

Table 4: The 10 most stressful of occupational stressors rated by respondents

Occupational stressors	n (%)
1. Patient having a medical emergency in the surgery (P)	498(92.0)
2. Risk of medicolegal complications (P)	464(86.1)
3. Actually making clinical mistakes (P)	403(70.8)
4. High patient expectations (P)	339(59.1)
5. The possibility of making mistakes (P)	326(58.2)
6. Running behind schedule (T)	246(42.9)
7. Working quickly to see as many patients as possible (T)	220(41.3)
8. Cross-infection risk (S)	228(40.9)
9. Maintaining high levels of concentration for long periods with few breaks (T)	231(40.5)
10. Equipment breakdown and defective materials (S)	232(40.4)

P = Patient-related, T = Time-related, I = Income-related, J = Job-related, S = Staff/technically related

Table 5: The difference in SPST scores and WSID scores according to personal and work-related factors (N=576)

Demographics	n(%)	Overall stress		Occupational stress	
		SPST scores (mean ± SD)	*p*-value	WSID scores (mean ± SD)	*p*-value
Personal factors	189(32.8)	45.53±16.98	0.929	73.94±18.34	0.426
1. Gender	387(67.2)	45.45±17.27		74.90±18.77	
Male					
Female					
2. Age (years)	152(26.4)	52.43±15.62	<0.001*	80.28±15.54	<0.001*
20-29	198(34.4)	47.50±16.38		76.57±16.11	
30-39	123(21.3)	39.92±16.50		69.30±21.33	
40-49	103(17.9)	37.95±16.75		68.67±20.65	
≥50					
3. Having underlying disease	118(20.5)	48.23±16.60	0.040*	74.90±18.50	0.462
Yes	458(79.5)	44.77±17.25		73.36±19.09	
No					
4. Exercise frequency	126(21.9)	47.52±16.62	0.026*	77.78±17.71	0.094
No exercise	256(44.4)	46.39±16.96		74.72±17.35	
1-2 times/week	194(33.7)	42.94±17.56		72.34±20.50	
≥3 times/week					
5. Marital status	343(59.5)	47.68±16.69	<0.001*	76.79±17.90	0.001*
Single	25(4.4)	48.84±19.64		75.36±18.02	
No single but unmarried	200(34.7)	40.96±16.80		70.42±19.29	
Married	4(0.7)	62.75±6.45		91.75±14.10	
Divorced	4(0.7)	43.75±20.53		72.00±18.62	
Bereaved					
6. Income per month (Baht)	16(2.8)	51.88±16.50	<0.001*	80.00±14.54	0.039*
≤30,000	119(20.6)	48.81±16.20		77.82±17.79	
30,001-50,000	137(23.8)	48.31±17.49		76.12±19.09	
50,001-70,000	162(28.1)	42.84±16.16		73.04±18.01	
70,001-100,000	142(24.6)	42.23±17.85		71.55±19.44	
> 100,000					
7. Number of persons under care	183(31.8)	47.15±18.68	0.263	76.86±17.63	0.198
None	270(46.8)	45.56±16.38		73.89±18.82	
1-2	101(17.6)	42.12±16.16		72.42±18.56	
3-4	22(3.8)	45.95±16.75		74.18±23.37	
>4					
8. Financial status	200(34.7)	42.14±18.24	<0.001*	71.47±20.00	0.006*
Income > Expense (≥50%)	287(49.8)	45.78±16.24		75.10±17.88	
Income > Expense (<50%)	69(12.0)	52.53±16.08		79.57±17.80	
Income = Expense	14(2.5)	52.00±15.25		83.21±13.18	
Income < Expense (<50%)	6(1.0)	45.83±12.53		76.33±11.34	
Income < Expense (≥50%)					
9. Graduate qualifications	305(53.0)	47.91±17.29	0.001*	76.29±18.95	0.024*
General practitioner	92(15.9)	46.04±17.15		75.23±15.67	
Postgraduate	108(18.8)	40.58±16.14		70.21±18.86	
M.D./Ph.D.	71(12.3)	41.70±16.23		73.07±19.50	
Resident					
Work-related factors	405(70.3)	46.90±16.56	0.001*	75.18±18.70	0.278
10. Sector of practice	171(29.7)	42.09±18.10		73.18±18.41	
Public					
Private					

11. Location of practice (work at hometown)	280(48.6)	43.38±16.93	0.002*	73.24±18.80	0.037*
Yes	296(51.4)	47.45±17.17		75.86±18.39	
No					
12. Years of practice	114(19.8)	52.08±15.85	<0.001*	79.75±15.60	<0.001*
<5	181(31.4)	49.64±16.25		78.85±15.06	
5-9	106(18.4)	41.43±15.88		71.58±19.51	
10-19	175(30.4)	39.31±17.03		68.63±21.11	
≥20					
13. Type of practice	464(80.6)	46.29±17.08	0.208	75.34±17.78	0.491
Dental Practitioner	55(9.5)	42.85±17.84		71.33±19.77	
Teacher	38(6.6)	39.87±15.22		71.11±20.74	
Dental Public Health Administrator	13(2.3)	45.54±20.98		71.46±29.68	
Public Health Administrator	4(0.7)	47.25±16.74		84.25±7.14	
Researcher	2(0.3)	30.50±6.36		55.50±51.62	
Others					
14. Hours of working per week	184(31.9)	44.54±17.98	0.385	72.88±19.60	0.295
≤35	210(36.5)	46.85±17.32		75.74±19.45	
35.1-42	182(31.6)	44.84±16.10		74.98±16.48	
≥42					
15. Ownership of dental clinic	127(22.0)	42.19±16.97	0.006*	69.65±19.16	0.001*
Yes	449(78.0)	46.41±17.12		75.98±18.24	
No					

The statistical analysis was performed by Mann-Whitney U test and Kruskal-Wallis H test, *p<0.05

Table 6: The results after adjusting for influence of the confounding variables of demographic and work-related information which significantly resulted in different overall and/or occupational stress scores using multiple regression analysis.

	Regression coefficients (B)		**Standard error**		***t*-value**		***p*-value**	
	SPST	WSID	SPST	WSID	SPST	WSID	SPST	WSID
(Constant)	49.70	1.71	6.95	0.25	7.15	6.79	0.000	0.000
Age	-3.66	-0.03	1.47	0.06	-2.50	-0.46	0.013*	0.643
Sector of practice	-2.38	-	1.67	-	-1.43	-	0.154	-
Location of practice	1.24	0.02	1.41	0.06	0.88	0.32	0.378	0.753
Having underlying disease	5.31	-	1.69	-	3.14	-	0.002*	-
Marital status	0.11	-0.02	0.79	0.04	0.14	-0.58	0.891	0.561
Graduate qualifications	-0.64	-0.04	0.69	0.03	-0.92	-1.48	0.356	0.138
Income per month	0.13	-0.01	0.72	0.03	0.18	-0.17	0.855	0.864
Financial status	2.78	0.04	0.89	0.04	3.13	1.16	0.002*	0.247
Exercise frequency	-0.45	-	0.95	-	-0.47	-	0.639	-
Years of practice	-1.14	-0.04	1.42	0.06	-0.80	-0.70	0.424	0.486
Ownership of dental clinic	-0.94	0.12	1.84	0.08	-0.51	1.49	0.612	0.136

*p<0.05

Stress-coping strategies

The most common coping strategies which respondents selected were 'spend time with hobbies' (n=510; 87.6%), followed by 'resting/sleeping' (n=464; 79.7%) and 'eating some delicious foods and beverages' (n=398; 68.4%). The least common strategy was 'take some medication to relief stress/anxiety/depression' (n=38; 6.5%) as shown in figure 1.

Discussion

Dentists' stress and correlation between overall and occupational stress

The study found that dentists had a mean SPST score of 45.48±17.16 which indicates a high level of stress, close to the scores of nurses (39.48-49.73±16.21-19.19)[17-19] and bank employees (47.24±0.98)[20], but lower than civil servants in the Revenue Office (54.76±21.17).[21] Considering the proportion of overall stress levels, it was similar to that of the staff at Maharaj Nakorn Chiang Mai Hospital and public sector dentists in Chiang Mai province, as most of the staff members and dentists had moderate to high levels of overall stress.[12,22]

Dentists had moderate to high levels of overall stress, but normal levels of occupational stress. According to Farmer *et al.*[23], there are four main sources of stress: personal, financial, relational, and occupational stress. As a result, it is possible that a dentist who experiences high levels of overall stress also experiences normal levels of occupational stress. However, this study also found a significant, positive correlation between overall stress and occupational stress, similar to previous studies[2-3] (r=0.34-0.68, p<0.001), and it can be said that occupational stress was associated with overall stress in a dentist's life, with work stressors contributing highly to overall stress.[3]

The most stressful stressors for dentists were patient-related, followed by time-related and staff-related or technical-related stressors, similar to Choy & Wong's study.[11] However, the result was different from Myers & Myers's study,[3] which found that the most of stressors were time-related, followed by patient-related and income-related stressors. In contrast, Bhat & Nyathi's study[2] found that the most stressors were job-related, followed by patient-related, income-related, and time-related stressors. In addition, 'patient having a medical

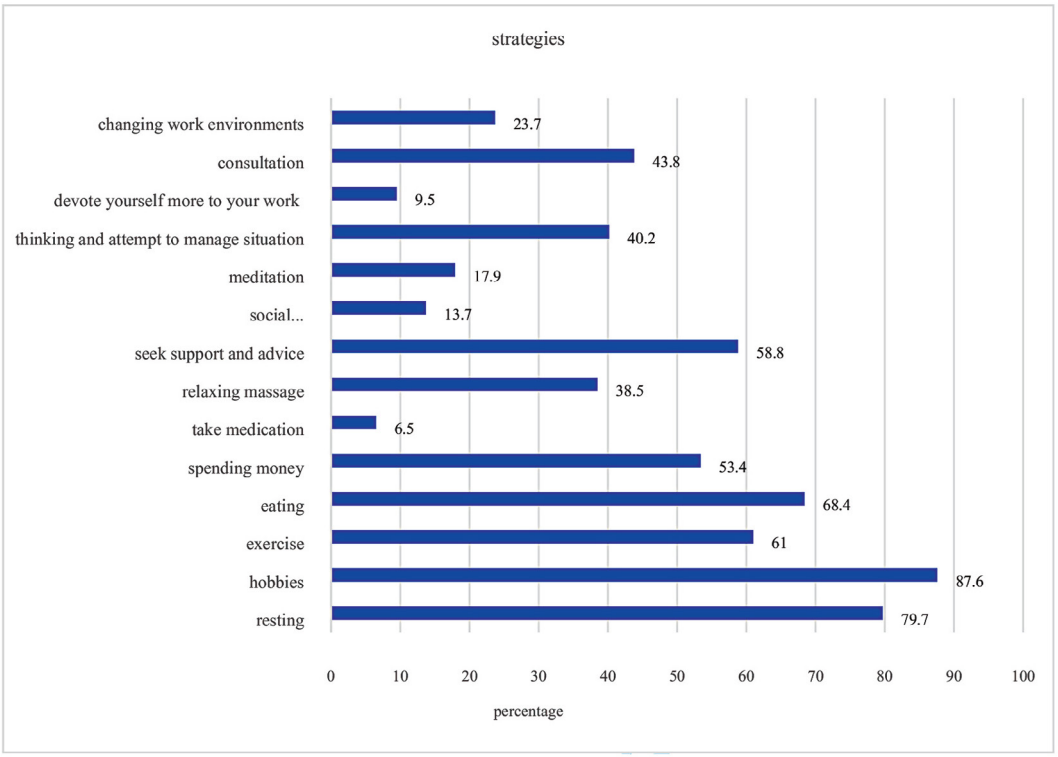

Figure 1. Strategies for coping with stress among dentists (N = 576).

emergency in the surgery' 'risk of medicolegal complications' and 'actually making clinical mistakes' were rated as most stressful by 70.8-92.0% of dentists, which were more than previous studies.[2,3,11] These stressors were shown to be the ones that affected dentists in this study the most.

As explained previously, we will notice that dentists in different countries placed different emphasis on each of the five domains of occupational stressors, depending on several factors or conditions in their countries, including the dental service system, political system, socioeconomic system, law and regulations, morals and beliefs, and social norms, as listed in Robbin's stress model.[24] Therefore, studying stress in dentistry within the context or condition of the country will lead to finding an efficient, direct solution to the issues and an impact at the macro level.

Factors affecting overall and occupational stress

Age was a significant factor affecting overall stress levels among dentists. Each age group of dentists experiences unique life characteristics. According to previous studies, younger dentists have reported being focused on striving to build their skills, knowledge, and confidence. These dentists frequently feared making mistakes, maintained a high standard, and sought to perform all tasks correctly, which required them to work at a slower pace, perhaps at the risk of upsetting patients or colleagues, and have a lower income due to the lower work volume. Most younger dentists thus tended to experience high levels of occupational stress. Younger dentists who worked outside of their hometown also tended to experience high levels of overall stress because they lacked the supportive bonds of family and friends, which made them feel isolated, insecure, and lonely. In addition, younger dentists might experience high levels of occupational stress due to either working in the public sector, which is characterized by strict regulations, low flexibility of work, limited career progression opportunities, and additional tasks beyond treating patients, or being the owner of a dental clinic, which requires management and problem-solving skills.[6,8-11,25] Although dentists who were married reported less stress than dentists who were single[26], but family problems could induce high overall stress levels if these problems resulted in a divorced or bereaved status. In contrast, most dentists who were older had high incomes and a secure financial status, which were two elements that reduced overall stress. Most older dentists had high professional positions, strong decision-making abilities, extensive experience, and the capacity to handle work stressors or unfavorable situations. As a result, most older dentists reported lower occupational stress levels and higher job satisfaction levels. However, most older dentists also reported higher levels of musculoskeletal pain, eye fatigue, and chronic diseases.[8,9,11,25,26] Stress and multi-site musculoskeletal pain often lead to poor sleep, and these three elements together can affect dentists' quality and quantity of work. Older dentists with health problems thus reported experiencing high levels of stress.[4,27]

Having underlying disease was affected in personal life, the results of the current study found that dentists who had underlying disease in every age group reported more stress than dentists without such diseases similar to Meyer's study.[9] One of the factors that influenced how people perceived stress was their current state of physical and mental health. Perceptions of stress and levels of stress tolerance also had an impact on how people reacted to stress, including the coping strategies they chose. Exercise was one of health behaviors that correlated with healthy physical and mental health.[28] There was a study found correlations between health behaviors and occupational stress indicated that high occupational stress was associated with less exercise[3], However, the current study found that exercise frequency was significant to effect overall stress but after adjusting for influences of the confounding variables, there was no correlation between these two factors.

Unhealthy financial status could induce high stress in personal life. Although high-income dentists reported less stress than low- to middle-income dentists[2,9], but the important thing was maintaining a secured financial status, so dentists who had expenses equal to or more than income tended to suffer significant levels of stress. Dentists, who had many children or persons in family under care reported significantly more overall stress than for those who were just caring for a few or none.[2,3] However, the current study, similar to Miron & Colosi's study[28], found that there was no significant correlation between number of persons under care and stress.

According to the findings of the current study discussed above, stressors varied depending on the age group of dentists. Understanding the relationship between age

and other factors could be useful for developing more effective strategic planning to reduce stress in dentists by age group that could more directly resolve this issue. Continuing study after graduated was the factor that reduced occupational stress in younger dentists similar to previous studies.[3,6,8,9,15] Therefore, motivating younger dentists to continue studying after graduated and assisting them to attend seminars, academic conferences, or regular workshops to develop knowledges and skills were effective methods for reduce occupational stress, and could help younger dentists worked confidently, efficiently, and happily. Motivating dentists, especially older dentists and dentists with underlying disease, to exercise or engage in sport activities was one of interesting strategies to help these dentists to be healthy, relief stress, and work happily. Additionally, encouraging dentists of all age groups to have financial literacy was the other one of interesting strategies that could help them maintain a healthy financial status and reduce the stress that comes with financial problems.

Coping strategies used among dentists

The results of a study on coping strategies used among dentists showed that over 50% of dentists use emotional-focused coping strategy similar to previous studies[2,6,28], reported that dentists tended not to apply problem-focused coping strategies for stress management. In contrast to Choy & Wong's study[15] found that the most prevalent method of coping with stress was 'try to control one's own working situation/condition' which was problem-focused coping strategy. However, there were only a few percentages of dentists in the current study selected 'take some medication to relief stress/anxiety/depression' and 'social gathering/smoking/alcohol consumption' as their coping strategy similar to previous studies.[6,16] According to previous studies[1,8,29], dentists should recommended to learn how to concentrate and pay attention to other things, participate in sports and relaxing activities, and strategies for stress prevention and management programs should be provided to dentists, and could be starting early as being a dental student. Providing consultation channels by psychologists was also an interesting strategy that could be used to reduce stress among dentists with severe level of stress.

Limitations and suggestions for future studies

The response rate of the current study was low (<30%) due to challenges in reaching the target population. Online surveys conducted through private dental groups on Facebook or Line may not accurately determine the receivers who have been approached, and online surveys sent to private chats could only be sent to people who have already been contacted. Additionally, the contact information from the Dentistry CMU Alumni Association, including email and postal addresses, was outdated, potentially resulting in some recipients not receiving the survey. To improve the likelihood of reaching the target population and obtaining more precise data, future studies should reassess the methods used to access dentists.

The current study was conducted in context of the COVID-19 pandemic, which has had a profound impact on society, the economy, and people's way of life. So, a follow-up study can be carried out to obtain more accurate results. Moreover, to enable better measures to be developed to address stress at the national level, the future study's scope should be expanded to cover all practicing dentists in Thailand, and to gain a deeper knowledge of the stress and coping mechanisms used by dentists in Thailand, a qualitative study should also be carried out.

Conclusions

The majority of dentists had normal levels of occupational stress, moderate to high levels of overall stress, and occupational stress significantly correlated with overall stress. There were a few factors that affect overall stress after adjusting for influences of the confounding variables. And there were a variety of stress coping strategies that dentists used for stress management. The findings of this study could be useful for strategic planning to prevent and resolve dentists' stress issues in the future.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Associations Between Oral Health Literacy and Oral Health Status Among Patients Attending Comprehensive Dental Clinic

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Abstract

Objectives: This study aimed to determine the association between oral health literacy (OHL), oral health status (OHS), and utilization of dental services among maintenance patients.

Methods: The study design was a cross-sectional study. Participants were maintenance patients attending the Comprehensive Dental Clinic, Faculty of Dentistry, Chiang Mai University from January to April 2021. Information about the participant's demographic details, including education, and income were collected using a questionnaire. The Decayed-Missing-Filled Teeth index (DMFT), Plaque Index (PI), and utilization of dental service were obtained from the electronic dental record. OHL was assessed using the Thai Version of Rapid Estimate of Adult Literacy in Dentistry (ThREALD-30). Data were analyzed using Spearman correlation and binary logistic regression.

Results: A total of 130 participants were recruited for this study. The mean age of participants was 51.1 years. The mean ThREALD-30 score was 26.7±3.76. The OHL scores were significantly negatively correlated with DMFT (r=-0.356; p=0.002), PI (r=-0.398; p<0.001), and utilization of dental services (r=-0.35, p<0.001). After adjusting for age ,gender, education and income, OHL was significantly associated with DMFT (OR=1.36 ;p=0.001), and PI (OR=1.26; p=0.006).

Conclusions: OHL was associated with OHS. Patients with high OHL had good OHS with regular annual dental examinations. An understanding of the OHL of patients is crucial for designing effective oral health education and creating intervention programs to promote oral health.

Keywords: comprehensive dental care, maintenance patients, oral health literacy, oral health status

Introduction

Oral health is a fundamental component of overall health that affects the quality of life. Oral health has been linked to lifestyle, mastication, the digestive system, and socialization regarding communication, personality, and self-confidence. Oral diseases impact health and reduce the quality of life, with higher national public health costs and increased study or work absenteeism.[1-4]

Oral diseases are associated with several risk factors including sugar consumption, tobacco use, alcohol use, and improper oral health care.[5-7] Therefore, the promotion of oral health not only eliminates the causes of oral diseases at any certain time, but also raises patient awareness about perceiving, understanding, receiving treatment, and maintaining oral health properly in continuous behavior.[7] Oral health literacy (OHL) is one of important factors that enables patients to maintain good oral health.[8,9]

OHL is the degree to which individuals have the capacity to obtain, process, and understand basic oral health information and services needed to make appropriate health decisions.[8] OHL is one of the essential factors that enables patients to search, understand, analyze, and evaluate the obtained information rationally to make decisions on behaviors that contribute to good oral health. In the previous studies, people with low OHL had a higher risk of developing poor oral health.[10-12] Furthermore, OHL was also associated with economic and social factors, education attainment, and the health care system.[13,14]

The Comprehensive Dental Clinic, Faculty of Dentistry, Chiang Mai University provides comprehensive dental care that focuses on understanding the whole patients in terms of biological, psychological, and sociological aspects. Patients attending the Comprehensive Dental Clinic receive full dental services for prevention, treatment, and oral rehabilitation. Patients who have completed dental treatment are transferred to become maintenance patients. All maintenance patients are recommended to attend dental recall appointments for dental checkups and received continuous care. As a result, OHL is one of the essential keys to keep good oral health during the maintenance phase of care. However, there has been no study to assess OHL and its association with oral health status (OHS) in maintenance patients.

It was hypothesized that patients with high OHL should have good oral health behaviors and be able to maintain optimal oral health. This study aimed to determine associations between OHL and different types of OHS among maintenance patients attending the Comprehensive Dental Clinic.

Materials and Methods

Study participants and ethical approvals

This research study had been reviewed and approved by the Human Experimentation Committee, Faculty of Dentistry, Chiang Mai University (No.12/2564).

The study population was maintenance patients who attended the comprehensive dental clinic, Faculty of Dentistry, Chiang Mai University, from January to April 2021. The population of maintenance patience who had a dentist appointment was 184. The sample size to estimate a population mean was calculated using the formula of $n = NZ_{\alpha/2}^2\sigma^2 / [(N-1)\, d^2 + Z_{\alpha/2}^2\sigma^2]$.[15] We adopted the confidence interval of 95%, the standard deviation of 8.71[16], and precision of 0.87 (10% of standard deviation). The result from the sample size calculation was 125 participants.

Study design and setting

Multistage sampling was used in sequence. For stratified random sampling, the population was divided into small sub-groups corresponding to their age groups e.g., 20-29 years, 30-39 years, 40-49 years, 50-59 years, and 60-69 years. Proportional stratified random sampling was then undertaken then simple random sampling for each division of samples was done by casting lots.

Inclusion criteria were patients aged 20-69 years with an ability to use the Thai language for communication (listening, speaking, reading, and writing). They received the instruction on oral health care, oral disease prevention, treatment, and rehabilitation from the Comprehensive Dental Clinic until they were transferred into the maintenance status. Exclusion criteria were patients with a physical or mental impairment affecting their cognitive function and communication, those unable to perform oral hygiene self-care, and those unwilling to participate in the research.

On the day of the study, informed consent was obtained from the participants. The questionnaire was

administered after participants had given their written consent. The participants needed to complete the background information questionnaire. After completing the questionnaire, the participants underwent an OHL test. This study assessed OHL using the Thai Version of Rapid Estimate of Adult Literacy in Dentistry (ThREALD-30).[16] Since the data of this study were collected during the covid-19 pandemic. Data about Decayed, Missing, and Filled Teeth index (DMFT), Plaque Index (PI), and utilization of dental service were collected from the patient's electronic dental record. Data collection from the patient's electronic record reduces contact with the patient and minimizes interference with the dentist's treatment.

Study variables and statistical analysis

Independent and covariate variables

OHL was assessed by the ThREALD-30[16], translated from the Rapid Estimate of Adult Literacy in Dentistry (REALD-30) in the English version.[17] ThREALD-30 is a validated OHL assessment tool for measuring OHL in the Thai population.[16] ThREALD-30 is easy to use and is beneficial for screening the level of OHL. This tool consisted of 30 common dental words with various degrees of difficulty. A participant was requested to read each word aloud to a researcher, and correct pronunciation was scored 1. The total scores ranged from 0-30.

The background section of the questionnaire collected socio-demographic details including gender, age, education attainment (dichotomized into 'high School or lower' and 'college or higher'), and monthly income (dichotomized into 'equal or lower than THB10,000' and 'higher than THB10,000').

Outcome variables

The outcome variables in this study were OHS and utilization of dental services. OHS was evaluated using DMFT by WHO[18] and PI by Ainamo and Bay.[19] The dental service utilization collected information on the periods of oral health check-ups after the last dental service. The check-up periods were classified into 'within 12 months' and 'more than 12 months'.

The data were collected from the patients' electronic dental records, which were dental charts examined and recorded by the 6th-year dental students, Faculty of Dentistry, Chiang Mai University.

Statistical analysis

SPSS statistics Macintosh, version 23.0 (IBM Corp, Armonk, NY, USA) was used to analyze the data. Descriptive statistics including mean, standard deviation (S.D.), and percentage, were used to explain the general characteristics of the data. The associations between OHL and OHS and dental service utilization were analyzed using Spearman's rank correlation. To confirm the hypothesis that OHL was associated with OHS and dental service utilization, binary logistic regression was performed. The final model for each outcome was controlled for age, gender, educational level, and income. The statistical significance was set at a p-value less than 0.05.

Results

General characteristics

Participant characteristics are presented in Table 1. The number of participants was 130, comprising 69 males (53.1%) and 61 females (46.9%). The mean age was 51.08±13.69 years. Fifty percent of the participants had college or university qualifications. Approximately one-fourth of the participants had monthly incomes lower than THB 10,000. For dental service utilization, the study participants were divided according to the length of time they received dental check-ups after their last dental visit. It was found that most of the participants came for dental check-ups within 12 months of 103 (79.2%).

The mean score of ThREALD-30 in this study was 26.7±3.76. The maximum score among the participants was 30 and the minimum score was 11. There were of 32 participants (24.6%) with a maximum score of 30.

In Table 2, the mean of DMFT was 5.11±3.23 teeth/person. When the individual components of DMFT were analyzed, it was found that the highest proportion of filled teeth (FT) was 3.56±2.43 teeth/person, followed by missing teeth (MT) of 0.99±1.47 tooth/person, and the lowest proportion of decay teeth (DT) was 0.54±0.78 tooth/person. The mean of PI was 1.29±0.50.

The associations between oral health literacy and oral health statuses

The associations between OHL and OHS in Table 3 presented that OHL significantly showed a negative correlation with DMFT (r=-0.356; p=0.002), decayed teeth (r=-0.283; p=0.001), missing teeth (r=-0.346; p<0.001),

and PI (r=-0.398; p<0.001).

Binary logistic regression analyses were performed to predict the variables affecting DMFT and PI demonstrated in Table 4. The mean of participants' DMFT was used to dichotomize the variable. Participants who had DMFT higher than the mean of the group (DMFT>5.11) were classified into a group "0" and the ones who did not meet this cut-off were categorized into a group "1". Additionally, the mean of participants' PI was used to dichotomize the variable into 2 groups. Participants who had PI higher than the mean of the group (PI>1.29) were classified into a group "0" and ones who had PI scores lower than the mean were categorized into a group "1". When adjusted by controlled variables (age, gender, education, and income) in the binary logistic regression models (Model II), the results displayed that OHL could significantly predict DMFT (Adjust OR 1.36, p=0.001), and PI (Adjust OR 1.26, p=0.006). When the individual components of DMFT were binary logistic regression analyzed, the results displayed that OHL could significantly predict Missing teeth (MT) (Adjust OR 1.26, p=0.003), not significantly predict Decayed teeth (DT) (Adjusted OR=1.14, p=0.098) and Filled teeth (FT) (Adjusted OR=1.22, p=0.010).

The association between oral health literacy and dental service utilization

An analysis of the association between OHL and dental service utilization found that OHL scores were correlated with the periods of an oral health checkup after the last dental service with statistical significance (r=-0.35, p<0.001).

The binary logistic regression analyses were used to confirm this association presented in Table 5. In the univariate analysis (Model I), OHL was able to predict the use of dental services within 12 months (Crude OR=1.24, p<0.001). However, when adjusted by controlled variables (age, gender, education, and income) in Model II, the association between OHL and dental service utilization was not significant (Adjusted OR=1.14, p=0.083).

Table 1: Socio-demographic characteristics and dental service utilization of the participants.

Characteristics	N	Percentage
Gender		
Male	69	53.1
Female	61	46.9
Age (mean= 51.08, S.D. = 13.69)		
20-29	15	11.5
30-39	12	9.2
40-49	20	15.4
50-59	38	29.2
60-69	45	34.6
Education		
High School or lower	65	50.0
College or higher	65	50.0
Monthly income		
≤ THB 10,000	32	24.6
> THB 10,000	98	75.4
Last dental visit		
≤ 12 months	103	79.2
> 12 months	27	20.8

Table 2: Mean and standard deviation of oral health indices.

Oral health status	Mean ± S.D.
Decay-Missing-Filled Teeth (DMFT)	5.11 ± 3.23
Decay Teeth (DT)	0.54 ± 0.78
Missing Teeth (MT)	0.99 ± 1.47
Filled Teeth (FT)	3.56 ± 2.43
Plaque index (PI)	1.29 ± 0.50

Table 3: The correlation coefficient between oral health literacy and oral health status.

Oral health status	*r*	*p*-value
Overall DMFT	-0.356	0.002*
Decayed Teeth (DT)	-0.283	0.001*
Missing Teeth (MT)	-0.346	<0.001**
Filled Teeth (FT)	-0.148	0.093
Plaque index (PI)	-0.398	<0.001**

*p<0.01
**p<0.001

Table 4: Binary logistic regression analyses to confirm the associations between oral health literacy and oral health status.

	DMFT ≤ 5.11						PI ≤ 1.29					
	Univariate Analysis (Model I)			Multivariate Analysis (Model II)			Univariate Analysis (Model I)			Multivariate Analysis (Model II)		
	Crude OR	CI	*p*-value	Adjust OR	CI	*p*-value	Crude OR	CI	*p*-value	Adjust OR	CI	*p*-value
Independent variable												
ThREALD-30	1.21	1.08, 1.36	0.001*	1.36	1.14, 1.61	0.001*	1.30	1.14, 1.48	<0.001**	1.26	1.07, 1.48	0.006*
Confounding variable												
- Age				1.03	1.00, 1.06	0.034				1.01	0.99, 1.04	0.430
- Gender (female)				1.39	0.65, 2.99	0.395				0.87	0.41, 1.86	0.714
- Education (Collage or higher)				2.34	0.85, 6.42	0.099				0.95	0.37, 2.41	0.911
- Monthly income (>THB 10,000)				1.27	0.42, 3.86	0.672				0.60	0.20, 1.78	0.356

*p<0.01
**p<0.001

Table5: Binary logistic regression analysis to confirm the association between oral health literacy and dental service utilization.

	Visited the dentist in last 12 months (yes/no)					
	Model I			Model II		
	Crude OR	CI	*p*-value	Adjust OR	CI	*p*-value
Independent variable						
ThREALD-30	1.24	1.11, 1.39	<0.001*	1.14	0.98, 1.32	0.083
Confounding variable						
- Age				1.01	0.97, 1.05	0.624
- Gender (female)				1.14	0.45, 2.88	0.781
- Education (collage or higher)				0.62	0.18, 2.13	0.449
- Monthly income (>THB 10,000)				0.38	0.13, 1.16	0.089

*p<0.001

Discussions

In this study, our primary objective was to determine the association between OHL, OHS and utilization of dental services among maintenance patients. Our finding shows that OHL was significantly associated with OHS and dental service utilization. Those with higher OHL had a lower number of DMFT, lower PI, and received dental service for oral health checkups within 12 months after their last dental visit.

The ThREALD-30 scores of the participants in this study were relatively high with a mean score of 26.7±3.76, compared to the mean OHL scores in the validation study with a mean ThREALD-30 score of 20.12±8.71.[16] The reason could be because this study was purposively conducted in the Comprehensive Dental Clinic at the Faculty of Dentistry, Chiang Mai University. The participants included in this study were maintenance patients. These patients had been accessing healthcare services for treatment, rehabilitation, and the prevention of oral diseases along with full dental health education. Hence, they were more likely to have better OHL scores compared to the general Thai population. In this study, most of the participants are elderly. Therefore, the relationship between age and OHL/OHS are not analyzed.

This study found significant associations between OHL and OHS based on DMFT and PI. The result found that the participants had a mean DMFT of 5.11 teeth/person and found 39 participants with new tooth decay. Although the patient was in the maintenance phase, poor oral health behavior can lead to new tooth decay. A Previous study found low oral health literacy is associated with poor oral health behavior.[10] Statistical analysis in this study demonstrated a significant association between OHL and DMFT. This finding corresponded to the previous studies of Deeraksa *et al.*[16], Wanichsaithong *et al.*[20], and Haridas R *et al.*[21] When the individual components of DMFT were analyzed, OHL presented negative associations with the missing teeth (MT) and the decayed teeth (DT) which could be implied that a person with higher OHL was more likely to have fewer decayed and missing teeth. It was also congruent with the study conducted by Blizniuk *et al.*, indicating that patients with adequate OHL would lose fewer teeth than those with inadequate OHL.[22] In this study, OHL was not associated with the filled teeth (FT). This may be attributed to utilizing oral health services. OHL and OHS can change over time. Patients who have a higher number of fillings may be individuals with high OHL. Patients with high OHL have skills in taking care of oral health, recognizing the presence of the disease, and receiving appropriate dental care before disease progression.[23]

In addition, there was a negative association between OHL and PI. People with high OHL would have lower plaque on the teeth. This finding correlated with the previous study in the Brazilian adult population, which found that patients with low OHL had more plaques on the teeth[24], which reflected oral hygiene caused by oral self-care behaviors of each patient. Patients with low OHL were likely to have poor oral health behaviors, delayed diagnoses of medical conditions, no understanding of medical instructions, and poor adherence to medical instructions.[9,11,12,23,25-27] These consequently had resulted in poorer oral health status in patients with inadequate OHL.

In this study, dental service utilization for checkups was found significantly correlated with OHL scores. In the Comprehensive Clinic, the recommended duration for dental check-up depends on the risk of oral disease of each person. The period may be varied from every 3 months, 6 months or 12 months. However, within 12 months, everyone receives an appointment for a dental check-up at least 1 time. A group with higher OHL tended to utilize the dental service within 12 months after their last dental service. People with adequate OHL seem to understand the benefits of seeking timely dental care. The results were consistent with the finding of Jamieson LM *et al.*, which highlighted that people visiting a dentist for a period exceeding one year were likely to have low OHL when compared with people who visited dentists annually.[28] On the other hand, some studies found no significant association between dental utilization and OHL.[9,29] That could be because those studies did not classify the reasons for dental service utilization, such as routine care, prevention, or emergency dental care. The reasons for dental service utilization appear to affect the data analysis because people with low OHL would often visit the dentists for emergency care, but hardly for preventive dental services. In addition, this study found that 79.2% of the participants had visited and received a dental service for oral health checkups within 12 months after their last dental service, which was a relatively high percentage compared to the general Thai population.[30] It could be due to the

dental service at Comprehensive Dental Clinic aims to enable patients to optimize their oral health and develop self-care behaviors. Proper instruction for dental service is therefore emphasized by the dentists to all patients. They are annually recalled for a check-up visit, even in the absence of any symptoms. The recommended recall interval is specifically determined for each patient based on an assessment of previous disease severity and risk of occurrence of new dental disease. Consequently, most of the maintenance patients attending Comprehensive Dental Clinic are expected to have awareness regarding oral disease prevention and utilize dental services for oral health checkups regularly.

In the Comprehensive Clinic, the maintenance patients refer to those who have already received several dental services for prevention, treatment, and rehabilitation. Therefore, maintenance patients were expected to have optimal oral health status and can perform self-care behaviors in the long term. Self-care management includes good oral health behaviors, perception of oral health diseases and treatment needs, and regular oral health checkups. The results of this study prove our hypotheses and highlight the importance of the association between OHL and OHS and dental service utilization. Therefore, it is suggested that improving the OHL should be emphasized in the curriculum for prevention regimen in every patient because it presents to contribute sustainable oral health in each individual.

A limitation of the present study was its cross-sectional design which did not enable establishing cause and effect relationships. The tool used to assess OHL was based on the ThREALD-30 used for assessment of the functional OHL only. However, previous studies demonstrated word recognition test correlate well with comprehension and functional health literacy.[31] The DMFT and PI data representing OHS in this study were obtained from secondary data (medical records stored on an electronic database), and the examiners were not previously calibrated. However, this may not have much impact on the validity and reliability of the data since the measurements are routinely checked by dental specialists (faculty staff) before being entered into the electronic database.

Conclusions

OHL is associated with OHS. People with higher OHL are likely to have a lower number of DMFT and PI, which reflects better OHS compared to those with lower OHL. In terms of behaviors for dental service utilization, an association is found between OHL and behaviors for dental service utilization. People with higher OHL would visit and receive dental services for oral health checkups within 12 months after their last dental service. When adjusted by controlled variables (age, gender, education, and income), the present study shows that OHL can predict DMFT and PI with statistical significance.

Conflicts of Interest

The authors declare no conflicts of interest.

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A Study of Clinical Appearances, Histopathological Features, and Demographic Data in Patients with Oral Potentially Malignant Disorders

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Abstract

Background: Oral squamous cell carcinoma is the most common oral cancer. Oral potentially malignant disorders (OPMDs) can be detected before they turn into oral cancer, thus its prevalence and risk factors should be investigated.

Objectives: This research aims to study the prevalence, clinical appearances, histopathological features, and demographic data in patients with OPMDs in Faculty of dentistry, Chiang Mai University during 2017-2020, along with the relationship between dysplasia level and risk factors.

Methods: This was retrospective and analytical study. The following data were collected and analyzed according to patient's diagnosis: demographic data and behaviors, clinical appearances, and histopathological features.

Results: The mean age was 60.6±13.0 years, dominate by female (70.9%). The prevalence for each disease was as follow: leukoplakia (28.6%), erythroplakia (8.2%), lichen planus (39.7%), oral submucous fibrosis (2.2%), actinic cheilitis (3.1%), discoid lupus erythematosus (13.3%), lichenoid reaction (1.8%), and candidal leukoplakia (3.1%). Most disorders are found at buccal mucosa as white plaque or mixed red and white lesion along with burning sensation. In histopathological aspect, mild dysplasia was frequently found in all disorders except lichenoid reaction which no dysplasia was found. Fifty-nine percent of patients with smoking history were found with dysplasia while only 21% of non-smoking patients were found with dysplasia.

Conclusions: OPMDs are frequently found in elderly patients above 6th decade and mostly found in female patient. Lichen planus was the most common found among OPMDs. In this retrospective study the relationship between smoking habit and dysplasia was found. No malignancy transformation was found during the study period.

Keywords: actinic cheilitis, chronic hyperplastic candidiasis, discoid lupus erythematosus, erythroplakia, leukoplakia, lichenoid reaction, lichen planus, oral potentially malignant disorder, oral submucous fibrosis

Introduction

Oral cancer is one of the ten most common cancers found in humans worldwide, and also considered at the top five in Thailand. The most common type is squamous cell carcinoma.(1) Oral potentially malignant disorders (OPMDs) such as leukoplakia, erythroplakia, lichen planus, oral submucous fibrosis, palatal lesions in reverse smokers, actinic cheilitis, discoid lupus erythematosus, hereditary cancer syndromes, lichenoid reaction, and candidal leukoplakia are usually found before cancerous lesions emerge.(2) In previous retrospective study reported 7.62% of OPMDs patient diagnosed as epithelial dysplasia had malignant transformation.(3) Cancer risk factor such as smoking and alcohol consumption were reported to increase the prevalence of overall OPMDs and highten the chance of dysplasia found in histopathology for each disease.(4-7)

Leukoplakia is an oral lesion that appears as a white plaque, which distinguishes it from every other OPMDs as well as non-OPMDs.(2) Several risk factors can cause leukoplakia, such as smoking, but it can also occur spontaneously.(8) Leukoplakia is found in males more than females(2,9), usually at ages above 40 years, and its likelihood increases with age.(8,10) The most common site is the buccal mucosa.(1,11)

Leukoplakia can be clinically categorized into two types. The first is homogeneous leukoplakia, which is homogeneously white; this type is the more common. The second is non-homogeneous leukoplakia, which presents as an uneven mix of red and white.(11,12) The histology of leukoplakia can be observed as hyperkeratosis, mild dysplasia, moderate dysplasia, through to severe dysplasia and carcinoma *in situ*.(8) The most common features is hyperkeratosis.(1)

Erythroplakia presents as a red lesion that distinguishes it from every other OPMDs and non-OPMDs lesion.(13,14) It is usually found in patients with histories of smoking, alcohol consumption, betel nut chewing, or tobacco chewing.(14) It tends to occur in middle-aged to elderly male patients, and the most common sites are the soft palate, the floor of the mouth, and the ventral surface of the tongue.(13,14)

The clinical features are a red lesion, whose surface can be smooth or rough.(14) More than 50% of histopathological features demonstrate epithelial dysplasia.(15) Of all dysplasia cases, 25% are mild to moderate dysplasia, 47.4% are severe dysplasia, and 27.3% are carcinoma *in situ*.(16)

Lichen planus can be a white lesion, or a mixed red and white lesion with patterns such as erythema, atrophy, and erosion together with fine white lines or dots called Wickham's striae. This lesion is commonly found in women aged above 50 years.(17,18)

The histopathology is unique, featuring band-like lymphocytic infiltration at the connective tissue layer close to the basal lamina. Acanthosis and hyperkeratosis may be found, and liquefactive degeneration of the basal cell layer is common.(18) The most common site for lichen planus is the buccal mucosa.(19)

Oral submucous fibrosis is characterized by submucosal fibrosis due to abnormal collagen production, resulting in rigidity and pale coloration or a marble-like lesion of the affected area.(20) Patients usually present with trismus, xerostomia, and a burning sensation.(21) In severe cases, patients might have difficulty speaking, swallowing, and maintaining oral hygiene. This disease is found mostly in females aged 11-60 years, most commonly in the 45-50 age range(22), and its most common site is the buccal mucosa.(23) Oral submucosal fibrosis is strongly related to betel nut chewing.(20) The histopathology features atrophic epithelium with fibrosis in the connective tissue from collagen deposition.(24)

Palatal lesions in reverse smokers, i.e., those who smoke with the lit end in the oral cavity, tend to be found

in particular regions such as India and South America. The clinical appearance can be vary as a white lesion, a red lesion, or a mixed white and red lesion on the palate with ulceration.[25] Nicotinic stomatitis lesions can also be found, with hyperkeratosis of the palate, and salivary gland inflammation showing as a red dot appearance on the palate.[26-28]

Actinic cheilitis is usually found on the lower lip, resulting from long exposure to sunlight. The clinical presentation is a white lesion on the lip with a dry, rough surface like sandpaper. Patients usually feel tightness in their lips.[29]

The histopathology could show atrophy or hyperplasia of squamous cells in the epithelium, dysplasia keratinocytes, and drop-shaped rete pegs but with the basement membrane remaining intact.[29]

Discoid lupus erythematosus is characterized by a round skin rash with defined margins and dilated capillaries at the border.[30-32] In the oral cavity, it is usually found as a round, white lesion, featuring an elevated border with white striae.[32,33] It is commonly found on the labial mucosa, lower lip, and buccal mucosa. Several predisposing factors are reported, such as genetics, smoking, diet, and some drugs.[30,34]

Common histopathological features are lymphocyte cell infiltration at the surrounding blood vessels, atrophic or hyperplastic epithelium, spongiosis at several layers, and diffuse inflammatory cells at the basement membrane layer and connective tissue.[30,35]

Hereditary cancer syndromes are a group of genetic disorders with a high risk of developing oral cancer: ataxia telangiectasia, Bloom syndrome, Fanconi anemia, Li-Fraumeni syndrome, and xeroderma pigmentosum.[36]

Lichenoid reactions can be divided into two subtypes: drug-induced oral lichenoid reactions and lichenoid contact lesions. The clinical appearances of these diseases are similar to lichen planus.[37]

Several drugs are reported to induce oral lichenoid reactions, such as nonsteroidal anti-inflammatory drugs (NSAIDs) and angiotensin-converting enzyme inhibitors (ACEIs); the latter have the highest chance of inducing lesions.[38] Lichenoid contact lesion is commonly found as a white plaque or striae in the oral soft tissue in close contact with dental materials such as amalgam or crown restorations.[39,40]

The histopathological features are orthokeratinized squamous epithelium with liquefactive degeneration of keratinocytes and lymphocyte infiltration at the submucosa.[39]

Chronic hyperplastic candidiasis or **candidal leukoplakia** is a less common lesion caused by *Candida* spp. infection.[41] Common clinical characteristics can be divided into two categories: the first is a white plaque that cannot be wiped off, usually without accompanying symptoms. The second is white nodules or speckles with a burning sensation.[42] Several risk factors exist for this lesion, such as smoking, vitamin deficiency, and immunosuppression.[43] The disease is more common in males than females, and it is usually found in ages above 50 years.[44] The most common site is the buccal mucosa.[42,44]

The histopathological features are epithelial hyperplasia, dysplasia, Candida hyphae at superficial areas, and multinucleated white blood cells.[45] In some cases, Candida hyphae will invade the junctional area between the keratin and spinous layers.[44]

The objective of this study was to observe and collect data from a database to identify the demographic data, clinical characteristics, symptoms and histopathological features of each OPMDs. In addition, the relationships between risk factors and dysplasia level were studied.

Methodology

This is retrospective and analytical study of the recorded data from histology and oral examination data archive in Faculty of Dentistry, Chiang Mai University.

Ethical approval

This study was approved prior to the data collection by the Human Experimentation Committee, Faculty of Dentistry, Chiang Mai University, Thailand (NO.16/2020). Patients' identification data were not collected during the retropective study, hence the inform consent from each patient was not needed.

Sample selection

Inclusion criteria

Patients who arrived at the Oral Diagnosis Clinic, Faculty of Dentistry, Chiang Mai University, from 2017 to 2020, with a clinical and histopathological diagnosis

of an OPMDs: leukoplakia, erythroplakia, lichen planus, oral submucous fibrosis, palatal lesion in a reverse smoker, actinic cheilitis, discoid lupus erythematosus, lichenoid reaction, candidal leukoplakia, or a hereditary cancer syndrome.

Exclusion criteria

Patient with insufficient data.

- Hisptopathological reported as inadequate specimen

- Site or location of lesion, Patient symptoms were not reported

- Demographic data were not presented

Data collection method

Patients' data were collected regarding their histopathological diagnoses.

Demographic data and history: age, gender, oral hygiene, drug usage, smoking, alcohol consumption, UV exposure, betel nut chewing, ill-fitting dentures, medication, and medical and dental history.

Clinical characteristics: lesion color, size, border, texture, consistency, site, and symptom.

Histopathological features: histopathological features for each lesion were collected and categorized by the level of dysplasia, carcinoma in situ, hyperkeratosis, liquefactive degeneration, acanthosis, lymphocyte infiltration, fibrosis, collagen degradation, atrophy, and candidal infection.

Statistical analysis

All of the data were analyzed to determine relationships between disease prevalence, clinical and histopathological features, and patient demographic data. Data were analyzed with χ^2 testing and descriptive statistics, using SPSS version 25.0. All biopsy samples were re-analyzed by specialists. The intra-calibration was done by repeating 10 sequence of slides, twice and analyzed with 68.8 percentage of agreement.

Results

We included 561 patients from 2017 to 2020 with OPMDs. The patients were 70.9% females and 29.1% males, with ages ranging from 18 to 87 years and a mean age of 60.6±13.0 years. Some patients had more than one biopsy results, hence the 649 data samples involved (only samples from same patients with different diagnosis were counted as another samples, if new samples had similar diagnosis as the previous reports, there would be omitted). The prevalence for each OPMDs is shown in Table 1. Lichen planus was the most prevalent, with 39.7% prevalence rate.

In this study, only smoking habit was analysed as it was the only properly recored risk factor in data archive. Dysplasia was found in 20.2% of patients without a smoking history, compared with 58.8% of patients with a smoking history (Table 2). In the non-smoking group, 79.8% of the cases were found as non dysplasia while 16.4% were found as mild dysplasia and 3.8% were found as moderate dysplasia. In the smoking group, 41.2% of the case were found as non dysplasia while 43.8% were found as mild dysplasia, 12.4% were moderate and 2.6% were severe dysplasia (Figure 1) (CI=51.7 (p>0.001)). Only eight out of among 10 OPMDs were found during the studied period; palatal lesions in reverse smokers and hereditary cancer syndromes were not found and were excluded from this study. The total sum of clinical appearance and site in some diseases might exceed 100% due to more than one features and sites were reported in some cases. If the clinical characteristics or symptoms were not identified in data record, it would be categorized as "unidentified".

Leukoplakia was more frequently found in females (63.2%) than males (36.8%), with a mean age of 66.0±11.1 years (Table 1). Lesions were mostly found on the buccal mucosa (44.5%), followed by the soft palate (11.6%), gingiva (8.8%), lateral of tongue (7.7%), lower lip(5.5%), alveolar mucosa (5.5%), vestibule (4.4%), ventral of tongue (4.4%), labial mucosa (2.2%), retromolar area (2.2%), dorsal of tongue (1.6%), Floor of mouth (1.1%), corner of mouth (0.5%) (Figure 2). Patient usually have no symptoms (71.2%) or burning sensation (21.1%) and pain (7.7%) (Table 3); 78.5% of lesions were found as a plaque, followed by reticular (7.6%), nodules speckles (7.6%), papular (1.2%) and unidentified (5.1%) (Table 3). Every lesion were found in white color (Table 3). The most common histopathological features were hyperkeratosis (44.8%), followed by Acanthosis (4.9%) and atrophy of epithelial layers(0.5%) were also found to be reported (Figure 3). 43.6% of the cases were found to be mild dysplasia, followed by moderate dysplasia (9.4%), and severe dysplasia (2.2%) (Figure 4). Moreover, 87% of patients with leukoplakia were found to chew betel nuts.

Erythroplakia/Erythroleukoplakia was found in females (56.3%) more than males (43.8%), with the mean age being 66.8±13.2 years (Table 1). The most common site was the gingiva (23.1%), followed by the buccal mucosa (15.4%), hard palate (13.7%), lower lip (8.0%), lateral of tongue (7.8%), soft palate (5.9%), dorsal of tongue (5.9%), ventral of tongue (5.9%), retromolar area (3.9%), vestibule (3.9%), alveolar mucosa (3.8%), upper lip (2.0%), floor of mouth (2.0%), labial mucosa (1.9%) (Figure 2). Patients usually reported a burning sensation (61.6%), no symptom (33.3%) and pain (5.1%) (Table 3). The most frequent clinical characteristic found was a patch or plaque (39.5%), reticular (32.6%), ulcerative (18.6%), nodular (9.3%), and unidentified (2.3%) (Table 3). Lesion came with mixed red and white in color (84.9%) or red color (15.1%) (Table 3). The predominant histopathology was mild dysplasia in (48.6%), followed by moderate dysplasia (14.3%), severe dysplasia (8.6%), non dysplasia (28.5%) (Figure 4). 25.7% was reported with hyperkeratosis and 2.9% was reported with atrophy of epithelial layers (Figure 3).

Lichen planus was found in females (77.5%) more than males (22.5%), with the mean age being 55.2±13.1 years (Table 1). The buccal mucosa was the most common site (70.0%), followed by the vestibular area (8.2%), gingiva (7.8%), lower lip (5.8%), Hard palate (3.1%), retromolar area (2.7%) lateral of tongue (2.7%), dorsal of tongue (2.7%), alveolar mucosa (2.3%), corner of mouth (1.2%), floor of mouth (0.8%) ventral of tongue (0.8%), labial mucosa (0.4%) (Figure 2). A burning sensation was a common symptom (73.9%) followed by no symptom (23.8%), and pain (2.3%) (Table 3). The most frequent clinical characteristic found was reticular (80.5%), then, patch or plaque (12.7%), ulcerative (11.0%), papular (0.8%), nodular or speckle (0.8%), and unidentified (2.5%) (Table 3). The most common color was mixed red and white (63.6%), wihite color (33.5%), red color (2.9%) (Table 3); Histopathological reported 91.3% of the cases as non dysplasia and 8.7% as mild dysplasia (Figure 4). Additionally 71.1% of the cases was reported as hyperkeratosis followed by acanthosis (15.1%), and atrophy of epithelial layer (7.8%) (Figure 3).

Oral submucous fibrosis was found in females (66.7%) more than males (33.3%), with the mean age being 66.1±14.7 years (Table 1). Every patient had history of betel nut chewing. The most common site was the buccal mucosa (71.4%), followed by the lower lip (14.4%), corner of mouth (7.1%), and soft palate (7.1%) (Figure 2). Patients usually reported a painful sensation (38.0%), then no symptom (37.0%), and burning sensation (25.0%) (Table 3). Paleness and firm of mucosal tissue at the buccal mucosa (64.3%) and lip (35.7%) was commonly found, along with paleness of the affected area (100%) (Table 3). Moderate dysplasia and non dysplasia were found in histopathological feature equally at 33.3%, Severe dysplasia and mild dysplasia also found equally at 16.7% (Figure 4). Additional histopathological features found were hyperkeratosis (58.3%), acanthosis (50.0%), atrophy of epithelial layer (41.7%) (Figure 3).

Actinic cheilitis was found in females (65.0%) more than males (35.0%), with a mean age of 65.1±10.4 years (Table 1). All of the cases were found on the lower lip (Figure 2). The most common symptom was a burning sensation (72.4%) followed by no symptom(13.8%) and pain (13.8%) (Table 3). Patch lesions were the most common clinical characteristic (60.0%), followed by ulceration (22.2%), reticular (5.6%), and nodular speckle (5.6%) (Table 3). Mix red and white color lesion were the most common (63.2%) followed by white lesion (26.3%), and red lesion (10.5%) (Table 3). Half of the cases were not found to have dysplasia in the histopathology followed by mild dysplasia (30.0%), moderate severe (10.0%), and severe dysplasia (10.0%) (Figure 4). Common histopathological features were hyperkeratosis (65.0%) and atrophy of epithelial layers (35.0%) (Figure 3).

Discoid lupus erythematosus was found in females (74.7%) more than males (25.3%), at a mean age of 57.8±12.8 years (Table 1). The most common site was the buccal mucosa (66.7%) followed by the lower lip (21.0%), gingiva (6.0%), alveolar mucosa (4.8%), soft palate (2.4%), upper lip (1.2%), vestibular area (1.2%), hard palate (1.2%), lateral of tongue (1.2%), dorsal of tongue (1.2%) (Figure 2). Burning sensation is the most common symptom (75.4%) followed by no symptom (14.5%), and pain (10.1%) (Table 3). The lesions were most often reticular features (74.4%), then ulcerative (24.1%), unidentified (9.0%), patch or plaque (6.3%), atrophic (2.5%), papular (2.5%), and nodular or speckle (1.3%) (Table 3). Most common color was mix red and white (76.5%), followed by white color (19.8%), and red color (3.7%) (Table 3). Most of the histopathology was hyperkeratosis (81.2%), with only 9.4% as acanthosis

and 5.9% as atrophy of epithelial layers (Figure 3); only 5.9% showed mild dysplasia while 94.1% did not show any dysplasia (Figure 4).

Lichenoid reactions were mostly found in females (75.0%) than male (25.0%), with a mean age of 58.7±8.8 years (Table 1). Every patient whose diagnosed as lichenoid drug reaction must had clear record of temporal relationship between related medicine or dental restoration and signs and symptoms of the diseases. The most common site was the buccal mucosa (91.7%), and the remaining was at gingiva (8.3%) (Figure 2). The most common symptom was a burning sensation (50.0%) followed by no symptom (33.3%) and pain (16.7%) (Table 3). The most common clinical feature was reticular (45.5%), followed by atrophic area (36.4%), and ulcerative lesion (18.1%) (Table 3). Mixed red and white coloration (58.3%) was mostly found follow by white lesion (33.4%) and red lesion (8.3%) (Table 3). No dysplasia was found in the histopathology (Figure 4); hyperkeratosis was the most commonly found feature (75.0%) with only 8.3% found with acanthosis (Figure 3).

Candidal leukoplakia was found in females (85.0%) more than males (15.0%), with a mean age of 65.2±8.3 years (Table 1). Sixty percent of lesions were found at the buccal mucosa followed by the lateral edge of the tongue (15.8%) with corner of mouth and floor of mouth equal at 5.0% while 14.2% was unidentified (Figure 2). The most common symptoms were a burning sensation (64.3%), no symptom (21.7%) and pain (14.0%) (Table 3). Patches or plaques (35.3%) was most common clinical characteristic found, followed by reticular (23.5%), nodular or speckle (5.9%) and unidentified (35.3%) (Table 3). Mixed red and white was the most common color (47.1%), followed by white lesion (41.0%) and brown lesion (11.9%) (Table 3). Only 2 patients were found to have a related medical condition. One of them had diabetes melitus together with dyslipidemia and the other had HIV infection. The most frequently found histopathological feature was hyperkeratosis (94.7%), followed by acanthosis (52.6%), and atrophy of epithelial layers (5.3%) (Figure 3). Non dysplasia and mild dysplasia was found equally at 47.2%, only 5.6% of the case was found as severe dysplasia (Figure 4).

Table 1: The number and percentage of males and females, age range, mean ages, and prevalence for each OPMDs, 2017-2020.

Lesion	Gender (N/%)		Age (years)			Prevalence (N/%)
	Male	Female	Range	Mean	SD	
Leukoplakia	68/36.8	118/63.2	50-81	66.0	11.1	186/28.6
Erythroplakia/Erythroleukoplakia	23/43.8	30/56.3	43-75	66.8	13.2	53/8.2
Lichen planus	58/22.5	200/77.5	32-70	55.2	13.1	258/39.7
Oral submucous fibrosis	5/33.3	9/66.7	18-87	66.1	14.7	14/2.2
Actinic cheilitis	7/35.0	13/65.0	44-79	65.1	10.4	20/3.1
Discoid lupus erythematosus	22/25.3	64/74.7	38-72	57.8	12.8	86/13.3
Lichenoid reaction	3/25.0	9/75.0	54-68	58.7	8.8	12/1.8
Candidal leukoplakia	3/15.0	17/85.0	46-81	65.2	8.3	20/3.1

Table 2: The percentages of dysplasia in the non-smoking group and smoking group 2017-2020.

	No dysplasia	Dysplasia
Non-smoking	79.8	20.2
Smoking	41.2	58.8

Table 3: The percentage of symptoms, clinical appearances and lesion color for each OPMDs, 2017-2020.

Disease	Symptoms			Clinical appearances								Color				
	Burning sensation	Pain	No symptom	Reticular	Ulcerative	Patch or plaque	Nodular or speckle	Papular	Atrophic	Paleness and firm of mucosal tissue	Unidentified	Red	White	Mix red and white	Brown	Paleness of tissue
Leukoplakia	21.1	7.7	71.2	7.6	-	78.5	7.6	1.2	-	-	5.1	-	100	-	-	-
Erythroplakia/ erythroleuko-plakia	61.6	5.1	33.3	32.6	18.6	39.5	9.3	-	-	-	2.3	15.1	-	84.9	-	-
Lichen planus	73.9	2.3	23.8	80.5	11.0	12.7	0.8	0.8	-	-	2.5	2.9	33.5	63.6	-	-
Oral submucous fibrosis	25.0	38.0	37.0	-	-	-	-	-	-	100.0	-	-	-	-	-	100.0
Actinic cheilitis	72.4	13.8	13.8	5.6	22.2	60.0	5.6	-	-	-	6.6	10.5	26.3	63.2	-	-
Discoid lupus erythematosus	75.4	10.1	14.5	74.4	24.1	6.3	1.3	2.5	2.5	-	9.0	3.7	19.8	76.5	-	-
Lichenoid reaction	50.0	16.7	33.3	45.5	18.1	-	-	-	36.4	-	-	8.3	33.4	58.3	-	-
Candidal leukoplakia	64.3	14.0	21.7	23.5	-	35.3	5.9	-	-	-	35.3	-	41.0	47.1	11.9	-

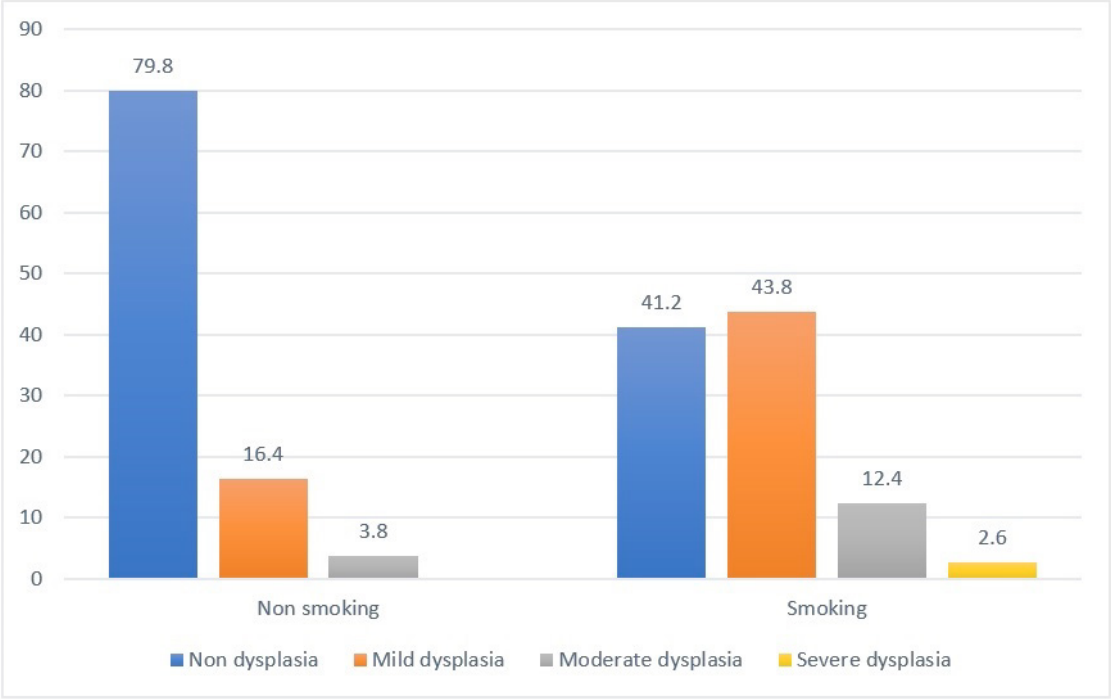

Figure 1: Percentages of patients with OPMDs categorized by smoking and level of dysplasia (CI = 51.7 (p>0.001))

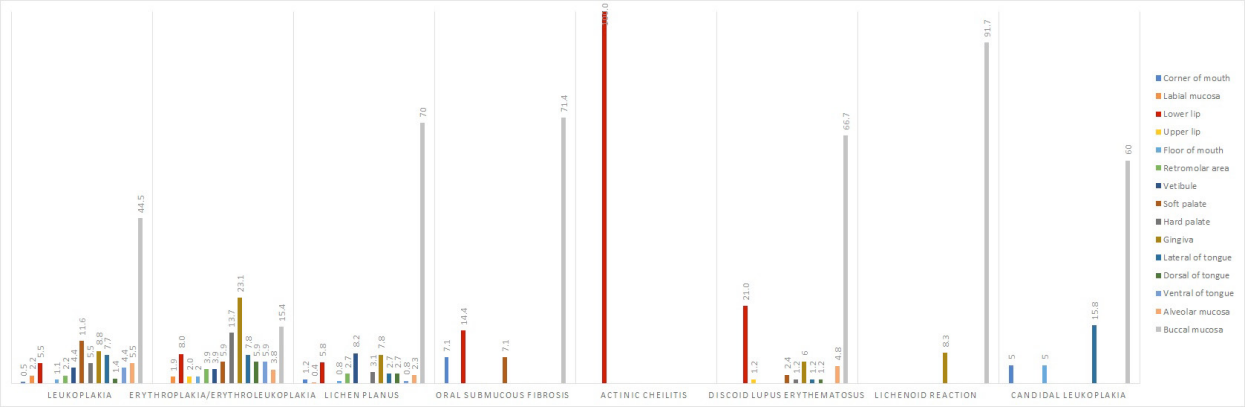

Figure 2: Percentage of lesion's sites categorized by OPMDs

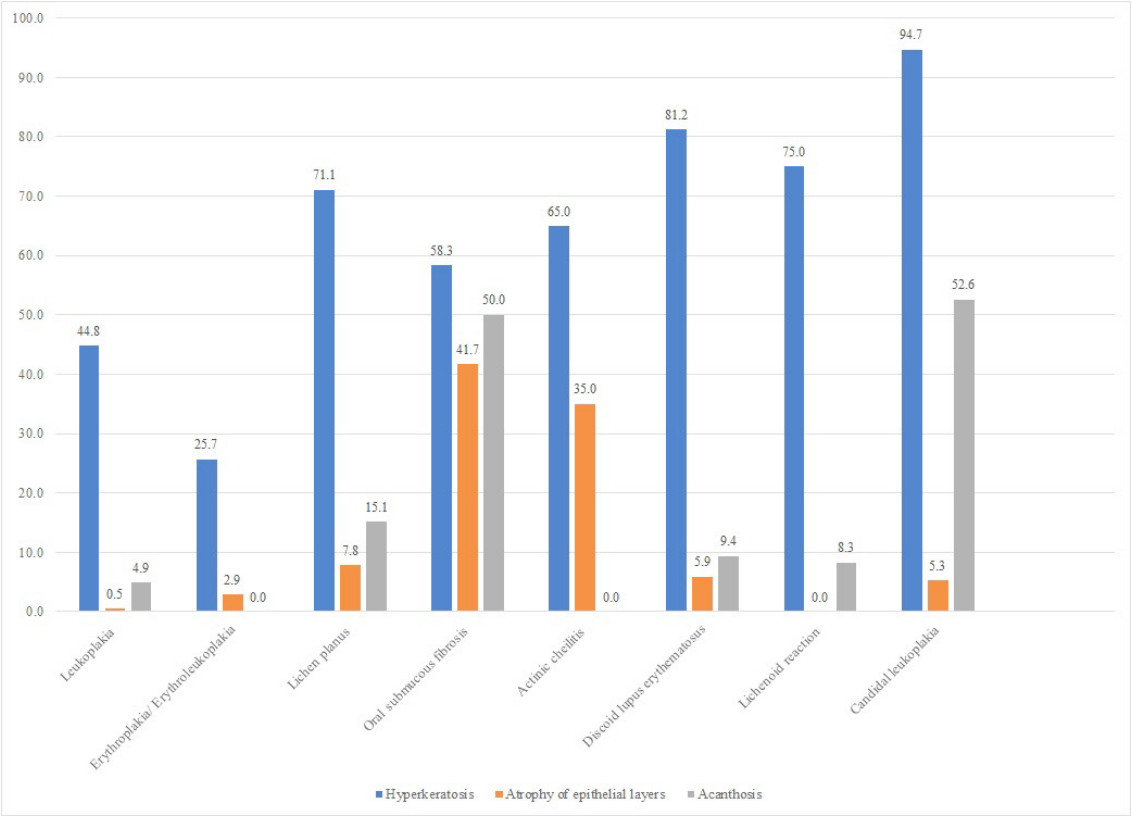

Figure 3: Percentage of common histopathological features categorized by OPMDs

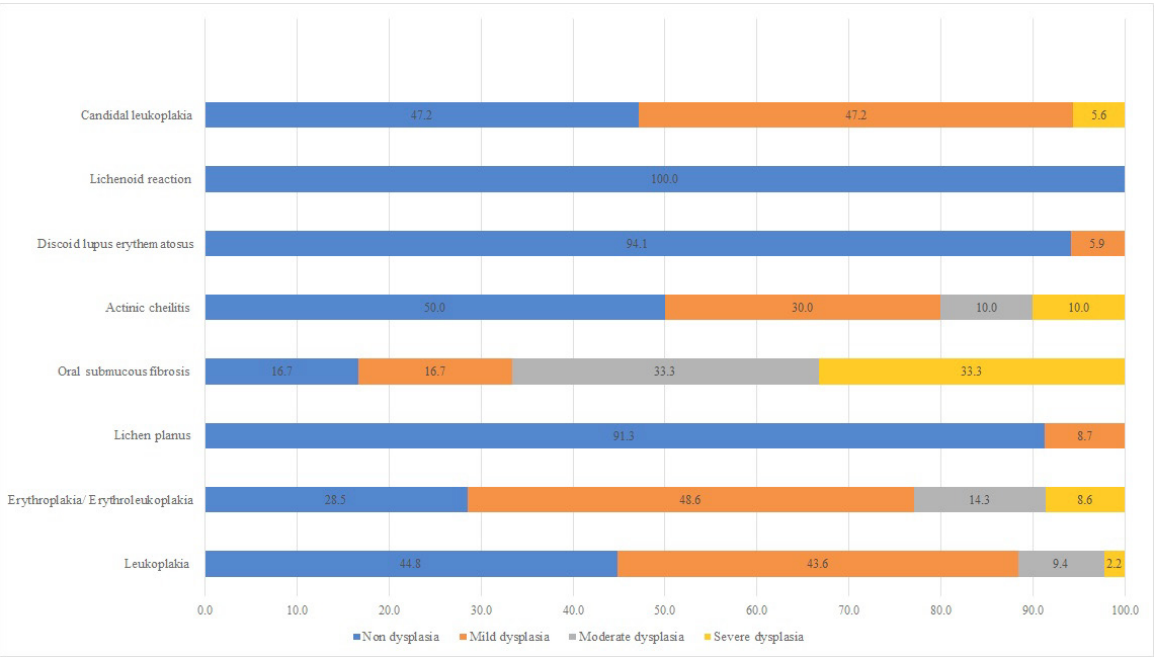

Figure 4: Percentage of dysplasia level found in histopathological result categorized by OPMDs

Discussion

The data were collected from the database of the Faculty of Dentistry, Chiang Mai University. All of the patients diagnosed with OPMDs during 2017-2020 were included, and patients with insufficient data were excluded. In total, 561 cases were included, mainly females (70.9%) and only 29.1% males. Their ages ranged from 18 to 87 years, with a mean age of 60.6±13.0 years which were corresponded to the previous crossectional study in Thailand, staging that the most prevalent age was between 6th to 7th decade and predominated by female patients.(46)

Lichen planus had the highest prevalence among all of the patients, which corresponds with literature reviews.(17,18) Leukoplakia and erythroplakia were found in females more than males, which contradicts other studies.(2,9) Several factors influenced the study's results, especially the gender representation ratio, since most of the patients included in this study were female. A study from Phudphong in 2020 also indicated that females have more concerns with oral health than males, hence the greater prevalence in female patients.(47)

Similar to previous reports, leukoplakia was found mostly at buccal mocusa with clinical characteristic as white plaque or patch.(1,11) Hyperkeratosis with non dysplasia was reported at 44.8% and 43.6% of the cases were report as mild dysplasia which conform with past report.(1,8) Eighty seven percent of the leukoplakia case was report with betel nut chewing habit, one of the greatest cancer risk factor and could be the cause of higher chance of epithelial dysplasia when compare to other previous studies.(1,8) Erythroplakia and erythroleukoplakia also show similar tendency as leukoplakia. In this study patient usually came with mixed red and white plaque or reticular which were conformed with other study.(14) However, contradict to the other study, burning sensation or pain at lesion site were found to be the most common symptoms in this study.(48) Over 70% of erythroplakia cases were found with epithelial dysplasia, significantly higher from another study(15), nevertheless most of dysplasia case were diagnosed as mild dysplasia (48.6% of total case or 68.0% of dysplasia case) with no carcinoma in situ reported, showing better prognosis when compare to other study which reported more higher level of dysplasia case.(16)

Recent study has reported that smoking, alcohol consumption, betel nut chewing, and tobacco chewing correlate with the occurrence of OPMDs; smoking was the most frequently found risk factor.(8) Some studies also indicated a higher prevalence of oral leukoplakia in smoking patients than in non-smoking patients, including a higher chance of finding dysplasia in smoking patients; this tendency was confirmed in this study.(9,10)

Lichen planus is the type of auto-immune disease. Lichen planus lesion reported in this study was found predominately at buccal mucosa, mixed red and white with burning sensation were the most common clinical characteristic found which are conformed with previous study.(19) Only 8.7% of lichen planus cases was found with mild dysplasia while the remaining cases were without dysplasia which were within range from previous study.(49)

Oral submucous fibrosis is characterized by epithelial inflmmatory reaction with progressive fibrosis of the submucosal tissues result in pale pink and rigidity of affected tissue similar to lesion found in the patient in this study. The disease is closely related with areca or betel nut chewing(20), several components such as tanins, arecoline and arecaidine can induce fibroblast stimulation and poliferation. Furthermore, it can inhibit collagenases hence reduce collagen degradation.(50) Strangely, the common symptoms of oral submucous fibrosis are burning sensation and pain(21), however around 37.0% of patients do not have any symptom at all. Possibly due to an early detection of the disease before symptom arise.

Actinic cheilitis is the type of OPMDs where epithelial cells or keratinocytes transform due to UV radiation and the most common location is lower lip as it prone to contact with sun light(29), which was correspond to the result from this study. Patient with actinic cheilitis has higher chance of having malignant transformation into squamous cell carcinoma (SCC). In addition, the cancer that occur on lower lip have higher chance (11 times) of metastasis when compare to SCC on other skin location.(51) In this study, up to 50% of the cases were diagnosed as dysplasia histopathologically.

Discoid lupus erythematosus is another type of auto-immune disease similar to lichen planus and could be clinically challanged to differentiate between these two disease. Lesion usually came as mixed red and white reticular appearance with burning sensation which are conformed with the result from this study.(32,33) Discoid lupus erythematosus is a subtype of lupus erythematosus disease and could occur as one of systemic lupus erythe-

matosus manifestation.[52] Therefore every patient diagnosed as discoid lupus erythematosus were requested to have their blood test for anti-nuclear antibody screening.[52]

Lichenoid reactions is also another type of autoimmune disease similar to lichen planus and difficult to distinguish from lichen planus even in histopathology.[37] The proper method to identified lichenoid reactions in both subtypes were through history taking especially lesion site and temporal relationship between the lesion occurance and timing of medication or dental restoration.[39,40] Similar to lichen planus common clinical appearance show mixed red and white reticular with burning sensation which correspond to this study result.

Candidal leukoplakia is described as white lesion that cannot be wipe off and show histopathological features similar to leukoplakia addition with *Candida* spp. infection detected in histological sample.[43] However, there were not possible to define from histological data alone whether *Candida* spp. infection was the cause of disease or patient originally had leukoplakia then infect with *Candida* spp. later on. *Candida* spp. infection is considered to be another cancer risk factor as show in this study; 47.2% of the cases were categorized as mild dysplasia and 5.6% were categorized as sever dysplasia.[43,45] According to previous reports, candidal leukoplakia might related to some medical conditions such as diabetes mellitus, asthma treated with steroid inhalers, and malabsorption syndrome.[53] However, due to lack of proper patient history information, those relationship could not be statistically analyzed.

Conclusion

There were total 649 biopsy samples from 561 patients. Most of the patients were female with overall mean age at 60.3±13.0 years. Almost every disease were found commonly at buccal mocusa, while burning sensation or pain with mixed red and white lesion were common symptoms found. Despite their unique histopathological characteristic, hyperkeratosis was the most common histopathological feature found in every OPMDs. Oral submucous fibrosis had highest dysplasia rate follow by leukoplakia and candidal leukoplakia while there were no epithelial dysplasia reported from patients with lichenoid reaction. Patients with smoking habit had significantly higher level of dysplasia when compared to non smoking group which was confirmed with other previous studies.

Limitations and summary

This was a retrospective study from a database. Some data were missing, such as demographic data and clinical features of lesions. Some diseases were not well-represented, namely erythroplakia, oral submucous fibrosis, angular cheilitis, and lichenoid reactions.

This study suggests that the history-taking and clinical data collection for each patient should be more systematic and detailed to minimize data errors and missing items, which will benefit both patient treatment and future research.

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Conflicts of interest

The authors declare no conflicts of interest.

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Chiang Mai Dental Journal

Original Article

The Satisfaction of Online Learning on Dentistry Students during COVID-19: The Faculty of Dentistry, Srinakharinwirot University

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Abstract

Objectives: To assess the level of satisfaction with online learning during the COVID-19 pandemic among dental students and lecturers at the Faculty of Dentistry, Srinakharinwirot University, Thailand.

Methods: A cross-sectional study based on an e-questionnaire (Google Forms®) distributed to dental students (n=427) and lecturers (n=67) from September to November 2022. Demographic data, experience and satisfaction with online learning were surveyed. Cronbach's alpha was calculated using the validity test of the questionnaire. Statistical analysis was descriptive and a t-test and ANOVA were performed (SPSS, $p<0.05$).

Results: The response rate was 53.43%. There was a statistically significant difference in the level of satisfaction with online learning during COVID-19 between students and lecturers ($p<0.01$). There was a statistically significant difference in satisfaction scores for the interactive aspects of online learning ($p<0.01$). Satisfaction scores of postgraduate students tended to be the highest of all groups while the lecturer's scores showed the least satisfaction. Perceptions of the advantages of online learning were at a good level in all groups.

Conclusions: Online learning was beneficial for learning continuity during the COVID-19 pandemic, particularly as a replacement for in-person lectures. The causes of dissatisfaction among lecturers should be further studied.

Keywords: COVID-19, dentistry students, online learning, satisfaction

Introduction

Since the start of the SARS-COV-2 outbreak in 2019, the high prevalence of the novel coronavirus disease 2019 (COVID-19) has been considered an international public health concern.[1] To prevent viral transmission by airborne droplets and close personal contact[2], during the pandemic, UNESCO estimates that 1.5 billion students globally did not attend school.[3] The virus affected clinics and dental schools in countries across the world.[4] The state was in lockdown for several months and dental staff, lecturers and students were instructed to remain in their homes to limit the spread of SARS-COV-2. The Faculty of Dentistry at Srinakharinwirot University (SWU) was closed during the COVID-19 lockdown. From February to August 2021 online education replaced onsite learning for the continuity of education in dental schools.

Successful online learning relies significantly on teaching perspectives, digital platforms, the experiences and attitudes of students and the technology and technical capacity of dental schools.[5,6] Studies of e-learning have demonstrated multiple benefits; classes can be arranged at any place and time and are accessible to many students or audiences.[7,8] However, there are limitations to the effectiveness of e-learning. All students are required to invest in equipment, including a personal computer, webcam and a stable internet connection[9], and the software and/or hardware used can also affect the learning process.[10] Technological skills training may be required for staff and students and the benefits of e-learning may be limited by the obsolescence of technology.[11] Traditional modes of teaching in dental schools includes lectures and involves learning clinical skills and practical work in clinics and the dental laboratory.

This study assessed the practical aspects, limitations, and satisfaction levels associated with online learning in addition to how the e-learning trend influenced satisfaction among dental students and lecturers in the SWU Faculty of Dentistry. No prior investigation or survey of satisfaction with E-learning among dental students and lecturers during the COVID-19 pandemic in the Faculty of Dentistry at SWU has been conducted.

Objectives

This study aimed to assess satisfaction with online learning among dental students and lecturers during the COVID-19 pandemic in the Faculty of Dentistry at SWU.

Materials and Methods

This cross-sectional study surveyed the level of satisfaction with online learning among dental students (preclinical, clinical and postgraduate level) and lecturers at the Faculty of Dentistry at SWU during the COVID-19 pandemic in Thailand. Ethics approval was granted by the Strategies Wisdom and Research Institute at SWU (SEC-336-2564). The sample size was calculated using the following formula[12] $n = N/(1+N(e)^2)$[12] where n denotes sample size; N denotes population; e denotes error = 0.05 and reliability is 95% (α=0.05). The total population (N) was 496 (Student=429, lecturer=67). The sample size was estimated to be 273, purposive sampling was used, and 265 subjects (53.43%) responded to the questionnaire. The inclusion criteria for purposive sampling were all levels of dental students or all lecturers at the Faculty of Dentistry, SWU who had experienced online learning during the COVID-19 pandemic. After the questionnaire was designed, the validity and reliability were approved by professionals in Education and Behavioral Sciences. Item-Objective Congruence (IOC) was used to evaluate the items on the questionnaire. Cronbach's alpha, α (or coefficient alpha), (developed by Lee Cronbach in 1951) measured the reliability or internal consistency. The IOC was greater than 0.8, and Cronbach's alpha was 0.82. The questionnaire was revised following trials by dental students and lecturers. The questionnaire was created online using Google Forms (www.google.com/forms/about/). The Google Form was distributed via LINE and social media for a duration of 1-3 months (September to November, 2022). The participants comprised dental students and lecturers at the Faculty of Dentistry at SWU (n=265). The undergraduate students invited to participate were at the preclinical level (the first to third year of study, total=193, respondents=103) and the clinical level (the fourth to sixth year of study, total=167, respondents=90). Postgraduate dental students (total=69, respondents=17) and lecturers (total=67, respondents=55) were also invited.

The questionnaire was divided into three parts: demographic information, the experience of online learning and satisfaction with online learning in the Faculty of Dentistry at SWU. A five-point Likert scale was used for assessment purposes. A score of five indicated the respondent was very satisfied, and a score of one indicated strong dissatisfaction. Descriptive statistical analysis was applied to demographic data using IBM SPSS Statistics

(Version 24 IBM Corp., Armonk, NY, USA). The significance level was set at less than 0.05. The satisfaction score of the Likert scale was compared between the groups and variables with the independent t-test and ANOVA.

Results

Student characteristics

210 dental students and 55 lecturers were surveyed. The dental students were undergraduates and postgraduates. The response rate for the preclinical level was 53.3%, clinical level 53.9% and postgraduate level 24.6%. Demographic data were obtained for age, gender, and level of education. The age distribution was 18-21 years 51.4% (n=108), 22-25 years 40.4% (n=85) and ≥26 years 8% (n=17). The gender distribution was 55 males (26.2%) and 155 females (73.8%), 49.9% (n=103) of students were at the preclinical level, 41.7% (n=86) were at the clinical level and 8.2% (n=17) were at the postgraduate level, as shown in Table 1.

Lecturer characteristics

55 lecturers were surveyed and demographic data were obtained for age, gender, and department of work. The age distribution was 24-33 years 16.3% (n=9), 34-43 years, 32.7% (n=18), 44-53 years 40% (n=22) and ≥54 years 10.9% (n=6). The gender distribution was 13 males (26.6%) and 42 females (76.4%). Of the lecturers 20% (n=11) were in the General Dentistry Department, 21.8% (n=12) were in Conservative Dentistry, 16.4% (n=9) were in Pedodontics, Orthodontics and Dental Public Health, 18.2% (n=10) were in Stomatology and Pharmacology and 23.6% (n=13) were in Oral and Maxillofacial surgery, as shown in Table 2.

Online learning in dental schools

Computer skills and online platforms. The self-reported computer skills of students were excellent (50%), good (47%) and poor (3%). The self-reported computer skills of lecturers were excellent (44%) and good (56%) (Figure 1). Overall, students reported higher confidence in their computer skills than lecturers.

Table 1: Participant characteristics (student group)

Variables	Number	% of individual
Age		
18-21	108	51.4
22-25	85	40.4
26+	17	8.0
Gender		
Male	55	26.2
Female	155	73.8
Year of the students		
Preclinical level		
The first-year	31	14.8
The second-year	28	13.3
The third-year	44	21
Clinical level		
The fourth-year	36	17.1
The fifth-year	20	9.5
The sixth-year	34	16.2
Postgraduate/		
Field of education		
Advanced general dentistry	5	2.4
Prosthodontics	2	1.0
Restorative	1	0.5
Endodontics	5	2.4
Maxillofacial surgery and Implant	2	1.0
Periodontics	2	1.0
Total	210	100

Table 2: Participant characteristics (lecturer group)

Variables	Number	% of individual
Age		
24-33	9	16.3
34-43	18	32.7
44-53	22	40
54+	6	10.9
Gender		
Male	13	26.6
Female	42	76.4
Department		
General dentistry department	11	20
Conservative and ProsthodonticDentistry	12	21.8
Pediatrics, Orthodontics and Dental Public Health	9	16.4
Stomatology and Pharmacology	10	18.2
Oral and Maxillofacial surgery	13	23.6
Total	55	100

Of online platforms, Microsoft Teams (MS Teams) was the most popular platform used by lecturers (52.9%), followed by Zoom (33.3%), Google Meet (2.9%) and other (4.9%). In the student groups, MS Teams (37.9%) and Zoom (33.7%) were the most popular, followed by Google Meet (15.1%), e-learning (12.6%) and other (0.8%).

Characteristics of learning in dental schools. At the preclinical level study, studies were primarily based around lectures relating to basic knowledge of human and dental sciences. At the clinical level, studies comprised clinical practice (80%), lectures, seminars and research projects (10%) and dental fieldwork (10%). Learning at the clinical level integrated clinical knowledge and skills for dental professionals. Postgraduate students learned higher specialty clinical skills via integration of lectures and clinical practice and dental research projects.

Satisfaction of students and lecturers. Dental students (n=210) and lecturers (n=55) were surveyed regarding their satisfaction with online learning. The mean satisfaction level with interactive learning was 3.5 and 3.1 respectively, learning activity 3.8 and 3.4 respectively, evaluation 3.6 and 3.9 respectively, technical support 3.2 and 3.4 respectively, academic support 3.2 and 3.4 respectively and advantage of online learning 4.5 and 4.1 respectively. There were statistically significant differences between the groups for learning activity (p<0.01) and evaluation (p<0.05) (Table 3). The dominant differences were in interactive learning and learning activities. Satisfaction levels were the same for technical and academic support. The advantages of online learning received a good satisfaction score in all groups. Analysis of the question related to satisfaction in all dimensions of learning and teaching was completed (Table 4) and Cronbach's alpha value exceeded 80%, which indicates reliability.

Satisfaction with interactive online learning. The statistical analysis was conducted using One-Way ANOVA. The mean satisfaction score for all participants on the topic of interactive learning (Figure 4) showed that students at the postgraduate level were most satisfied. There was a statistically significant difference in the mean satisfaction score of the lecturers compared to the other respondents (p<0.001). For the question-and-answer aspect of online learning, there was a statistically significant difference in mean satisfaction scores at the postgraduate level in comparison with students at the clinical level and lecturers (p<0.01). For class participation, there was a statistically significant difference in the mean satisfaction score of the postgraduate group in comparison with the students at the clinical level and lecturers (p<0.01). For sharing ideas, there was a statistically significant difference in the mean satisfaction score of lecturers compared to preclinical level and postgraduate students (p<0.01) (Table 5). The mean score of satisfaction was highest in the group of postgraduate students and lowest in the group of lecturers.

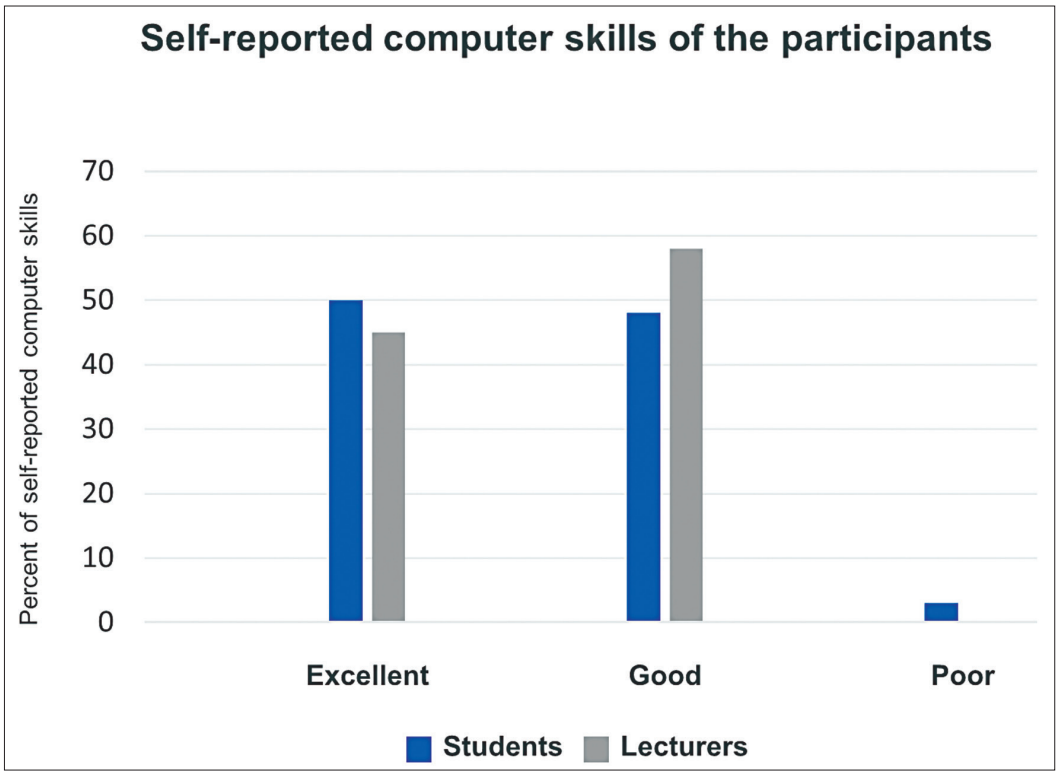

Figure 1: Self-reported computer skills of participants

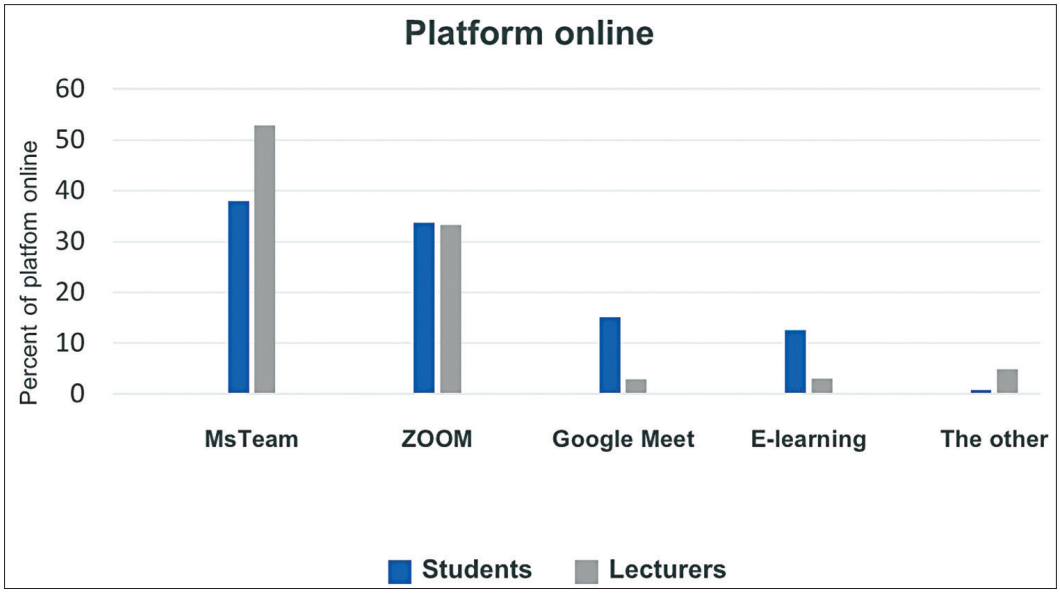

Figure 2: Platform used for online learning

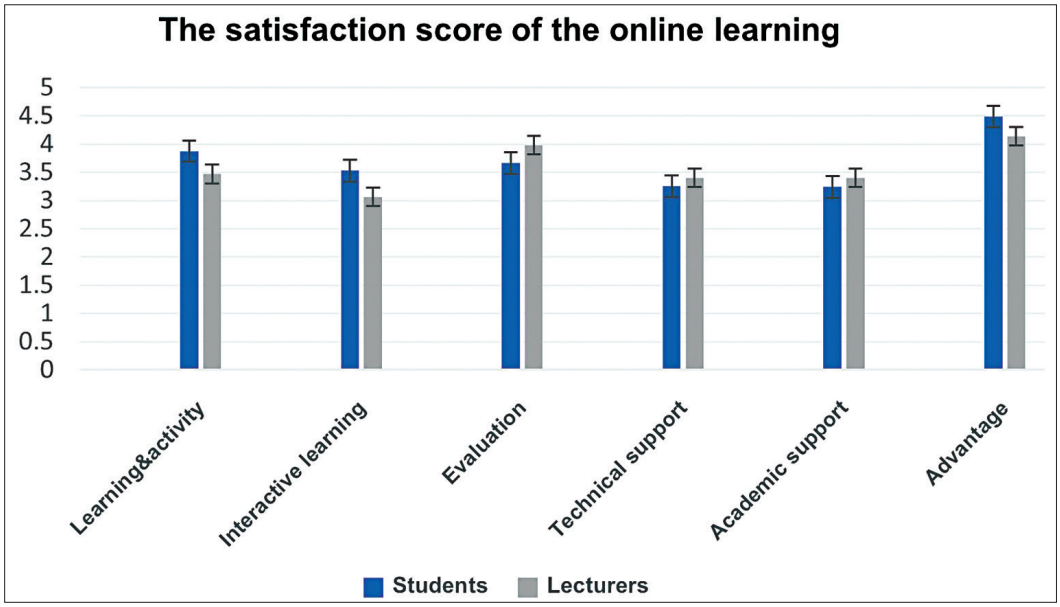

Figure 3: The mean satisfaction score of online learning among students and lecturers

Table 3: Satisfaction score of online learning between participants (t-test)

Question	Group	Mean	SD	*p*-value
Learning and Activities	Students	3.9	0.83	<0.001*
	Lecturers	3.5	0.61	
Interactive learning	Students	3.5	0.98	0.539
	Lecturers	3.1	1.03	
Evaluation	Students	3.7	0.94	0.022*
	Lecturers	4.0	0.93	
Technical support	Students	3.2	0.91	0.262
	Lecturers	3.4	0.86	
Academic support	Students	3.5	1.0	0.252
	Lecturers	3.4	0.86	
Advantages of online learning	Students	4.5	0.77	0.285
	Lecturers	4.1	0.77	

Statistical analysis for the satisfaction score of online learning comparison between students and lecturers (t-test)
(**p<0.01, *p<0.05)

Table 4: Reliability statistics for questions

Question	Cronbach's alpha	Number of items
Q.2 Learning activity	0.795	7
Q.4 Interactive learning	0.799	7
Q.5 Evaluation	0.873	7
Q.6 Technical support	0.906	7
Q.7 Academic support	0.822	7
Q.9 Advantage	0.819	7

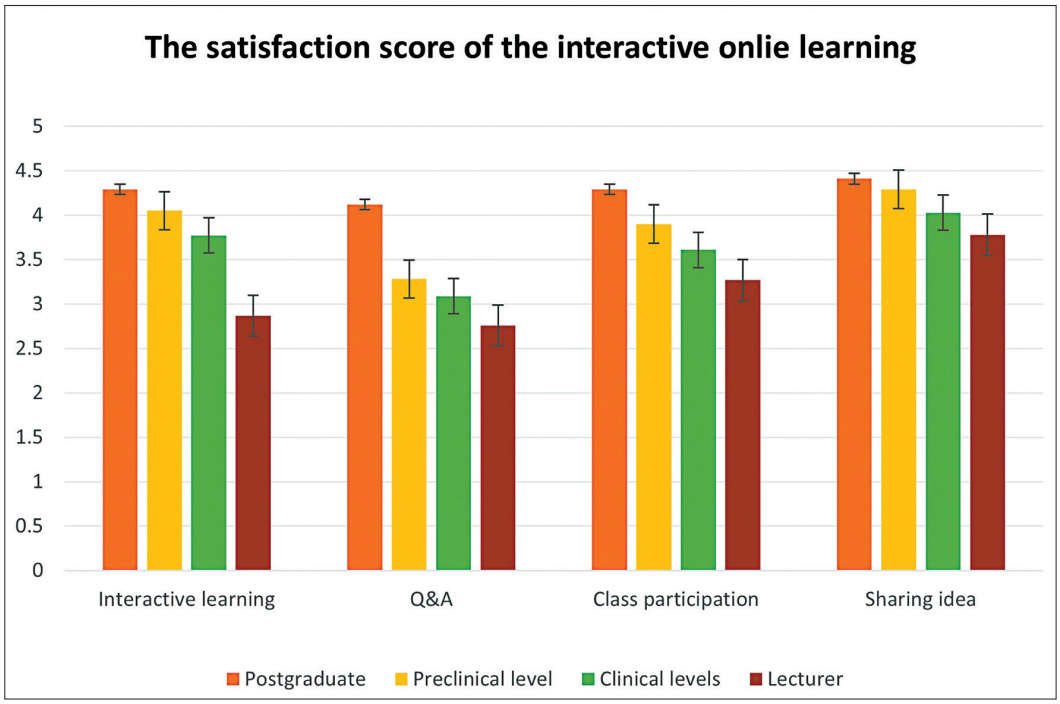

Figure 4: The differences in the satisfaction scores of the interactive online learning between all participants

Table 5: Differences in satisfaction scores of interactive online learning among participants

Topic	Group	Mean	SD	F-test	*p*-value	Post hoc test	*p*-value
Interactive learning	PG	4.29	0.84	24.47	<0.01	PG ≠LS	<0.001**
	PC	4.05	0.82			PC≠LS	<0.001**
	CL	3.77	0.79			CL≠LS	<0.001**
	LS	2.87	1.09				
Q&A	PG	4.12	0.69	6.40	<0.01	PG ≠LS	0.04
	PC	3.28	1.19			PC≠LS	<0.001**
	CL	3.09	1.21			CL≠LS	<0.001**
	LS	2.76	1.15				
Class participation	PG	4.20	0.77	9.27	<0.01	PG ≠LS	0.02*
	PC	3.90	0.88			PC≠LS	0.00*
	CL	3.60	0.80			CL≠LS	0.00*
	LS	3.20	0.85				
Sharing ideas	PG	4.40	0.69	0.00	<0.01	PG ≠LS	0.02*
	PC	4.30	1.19			PC≠LS	0.00*
	CL	4.00	1.21				
	LS	3.78	0.83				

PG = Postgraduate, PC = Pre-clinical, CL = Clinical, LS = Lecturers

Discussion and Conclusions

Online learning replaced many traditional learning styles during the COVID-19 pandemic and in particular lecture-based learning. This study surveyed satisfaction with online learning in the Faculty of Dentistry at SWU during the COVID-19 pandemic. The response rate of students and lecturers was 53.42%. There was a statistically significant difference in satisfaction with online learning between students and lecturers ($p<0.01$). There were also statistically significant differences in satisfaction with interactive online learning ($p<0.01$).

The results of the satisfaction scores between students and lecturers show that satisfaction with interactive learning was lower than other topics. Overall, the scores of the lecturers tended to be lower than the students. The advantage of online learning scored highest in all groups. The advantages included remote learning, comfort, and accessibility. The interactive aspect of online classes was identified as the most significant limitation and this indicates staff should receive training on using technology to facilitate interaction or developing lesson plans to increase interactive learning online.[13] The theories of active learning indicate that active online learning was applicable to dental students.[14] The interactive teaching methods in both offline and online platforms in Periodontics showed equivalent performances by undergraduate dental students. According to Kumar *et al*.[15], to facilitate interactive learning, instructors should shift their role from traditional lecturer to that of facilitator.

Among preclinical students, online learning may benefit the style of learning in lecture-based studies. Teaching material and an online learning platform can be developed for this group. Postgraduate students can learn individually and in small groups, and have clinical experience, as such, their reported satisfaction levels suggest this allowed them to adapt easily to the learning style for the situation.

The clinical study level was most impacted by the COVID-19 pandemic as the School was closed and the clinical practice ceased. Most dental schools in the United States and many countries, including Thailand, ceased clinical activity and simulation labs, except in the case of emergencies.[16] Lockdown reduced patient flow and patient incomes, which limited clinical practice. The characteristics of learning in clinical and preclinical students were different. Online learning was a significant limitation for the practice of clinical skills, both 'hands-on' and laboratory study. However, it is yet to be determined if online learning improves or reduces professional skills.[17] Most students did not feel confident clinically managing patients as an outcome of e-learning.[18] Online learning was satisfactory in acquiring knowledge but could have been more effective in acquiring clinical and technical skills.[19]

In the lecturer group, the primary teaching style was lecture-based teaching. Lecturer age, computer skill level, technical support and ability to adapt to new online teaching techniques may represent barriers to effective online teaching. The teaching experience of lecturers was based on the in-class participation of students. However, during online sessions, many students did not turn on their personal cameras and did not participate in discussions leading to one-way communication. Online learning promoted isolation and a lack of face-to-face interaction has been shown to contribute to professional isolation and a reduced learning experience.[20] From the perspective of the lecturers, they desired student participation and aimed to hold 'Q&A' sessions or develop a sense of participation among students.

Academic support for the internet and the online library was the main topic addressed by respondents. This indicates that universities should sufficiently support the internet system and access to technical assistance, e-journals and e-books for all staff. Computer devices, the internet and online learning platforms can represent major barriers to online learning. When teaching synchronous methods, staff require timely technical support when they have internet connectivity or other technical problems. If the system is unstable and the internet signal is not strong, it interrupts online learning.

With continuous improvements, online teaching and learning methods can become integral to the academic system. Progress and development in online learning remains necessary. Lack of resources, infrastructure, and training may be associated with low efficacy.[21,22] Online learning had a beneficial impact on learning continuity during lockdown allowing distance learning and revision of learning material. The results indicate that online learning might be suitable for lectures, seminars, or presentations. However, a key finding is that although students were satisfied with online learning, lecturers were not. Further study should investigate this discrepancy.

Acknowledgments

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