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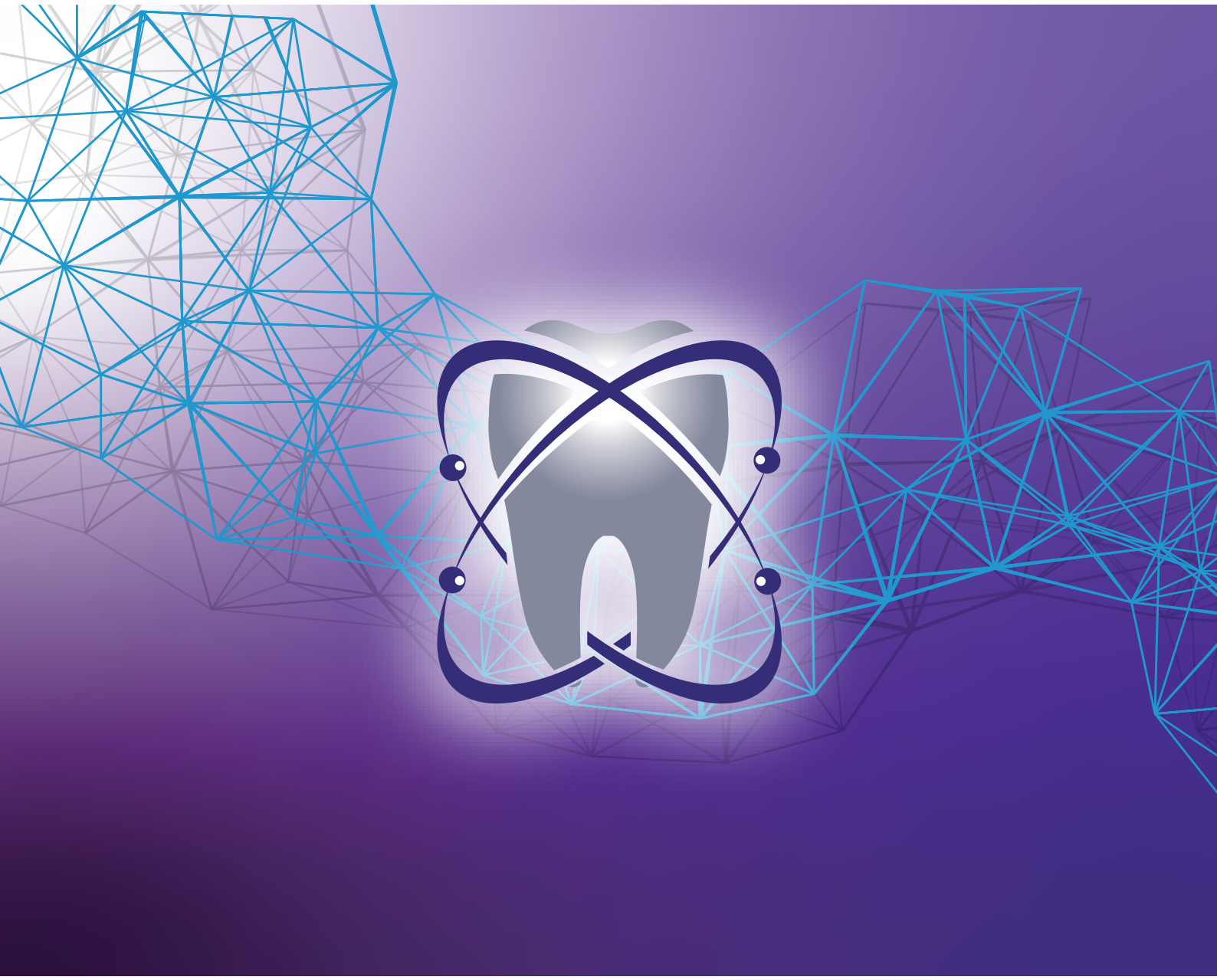

Chiang Mai Dental Journal

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.
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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.
4. Authors of articles are responsible to review and verify the accuracy of the text, images, tables in the articles before publication.
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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 Original articles	Original contributions of research reports or unpublished recent academic research to the development and applications in dentistry and related fields.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.

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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.

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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.

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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.

1. Original article

- *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.
- *Results* should show the data gained from the study's design in text, tables and/or illustrations, as appropriate, and be clear and concise.
- *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.

Formatting of funding source:

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.

- *References* should be confined to documents relating to the author's article or study. The number should not exceed 80, placed in order and using numbers which are superscripted and put in parentheses, starting with number 1 in the article and in reference document's name. (see 'References' section for more information regarding reference formatting)

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.
- Methods should be divided into logical sub-sections in order to improve readability and enhance understanding (e.g. details of protocol registration, literature search process, inclusion/exclusion criteria, data extraction, quality assessment, outcome(s) of interest, data synthesis and statistical analysis, quality of evidence).
- 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.

4. Case reports/series should be divided into Introduction, Case report, Discussion and Conclusions. They should be well illustrated with clinical images, radiographs and histologic figures and supporting tables where appropriate. However, all illustrations must be of the highest quality.

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.
5. Product identification: all products mentioned in the text should be identified with the name of the manufacturer, city, state, and country in parentheses after the first mention of the product, for example, The ceramic crown was cemented on dentin surface with resin cement (RelyX™ U200, 3M ESPE, St. Paul, MN, USA)...

D. Figures

Figures should be prepared and submitted separately from the main manuscript. Color artworks are encouraged at no additional charge. Regardless of the application used other than Microsoft Office, when the electronic artwork is

finalized, please 'save as 'or 'export 'or convert the images to **EPS, TIFF, or JPEG format with the minimum resolution of 300 dpi**. Keep the artwork in uniform lettering, sizing, and similar fonts. Please do not submit graphics that are too low in resolution or disproportionately large for the content. Authors must submit each illustration as a separate file.

Please ensure that each illustration has a caption according to their sequence in the text and supply captions separately in editable Microsoft Word processing file (.doc or .docx), not attached to the figure. A caption should comprise a brief title (not on the figure itself) and a description of the illustration. Keep text in the illustrations themselves to a minimum but explain all symbols and abbreviations used.

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F. References

Citation in text

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:

1. Journal article

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.

2.2. Book with no author

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

Note: Do not use anonymous. Please begin a reference with the title of the book if there is no person or organization identified as the author and no editors or translators are given.

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

Author - family name followed by initials. Thesis title [type of thesis]. Place of publication: Publisher; Year.

Example:

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

3.2. Thesis retrieved from full text database or internet

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

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

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

Title [Internet]. Place of publication (if available): Publisher's name (if available); Publication date or year [updated date (if available); cited date]. Available from: URL

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

Note: If the image does not have a title - give the image a meaningful title in square brackets.

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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Semi-permanent Restorations Just Temporary or Long-lasting Use?: A Review of the Literature

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Abstract

In some clinical situations, using a provisional fixed restoration for an extended period of time is unavoidable. However, traditional materials are unable to withstand this, resulting in restoration fracture, which leads to repair and/or replacement as well as increased chair time and treatment costs. Many practitioners have been developing their protocols to improve physical properties and longevities of these restorations. Currently, many manufacturers have launched novel products and several fabrication techniques; some are claimed to be "semi-permanent restoration" with improved strength and survivability. The purpose of this review article is to assist clinicians to decide the most appropriate provisional restorative materials for long-term usage in complex treatment procedures, including fabrication and cementation techniques.

Keywords: acrylic resin, cementation, composite resin, permanent restoration, provisional restoration

Introduction

The provisional restoration which usually infers to fixed restoration, may need to be able to survive up to 6 months or longer, under certain treatment plans.[1] However, the "semi-permanent restoration" or "long-term provisional restoration" is expected to last longer than the provisional restoration, but not as long as the permanent restoration. Müller *et al.*[2] characterized the semi-permanent materials as possessing adequate strength, which avoid failure while still provides reliable intended retrievability when needed. An indication of the provisional restorations includes a complicated prosthodontics case in which they are used for several months to assure and alter the occlusal surface to provide optimal guidance and functional scheme. They are also useful for evaluating soft tissue reactions and the restoration's acceptance. Moreover, patients can evaluate both esthetics and phonetics while having these restorations.

In addition to the advanced prosthodontic cases, provisional restorations can be used in several circumstances for various purposes. During the osseointegration process of a dental implant, semi-permanent restorations give the opportunity to load the implant progressively.[3] Furthermore, bruxism patients require stronger materials for the temporary restorations to decrease chair time for repair and/or replacement. In teeth with questionable prognosis or severe periodontitis which patient prefer not to undergo tooth extraction, these restorations can be used to reduce the treatment cost. In addition, they can be used in pediatric treatment with a high esthetic demand as well as in orthodontic treatment which requires a good longevity and bond with orthodontic adhesive. Lastly, semi-permanent restorations can reduce technician's fee and material cost compared to the permanent restorations which is very beneficial to the patients with low socioeconomic status. All of these applications massively improve treatment outcomes while making clinicians' work simpler.

Conventional provisional restoration materials can be divided into two groups according to their chemical composition including 1) Acrylic resin which based on monomethacrylates or acrylic resins, which include polymethyl methacrylate (PMMA) and polyethyl methacrylate) (PEMA) and 2) Composite resin which based on dimethacrylates or bis-acryl resins such as bisphenol A-glycidyl dimethacrylate (Bis-GMA) and urethane dimethacrylate (UDMA).[3] This review article summarizes the properties of provisional and semi-permanent restoration materials as well as the reinforcement and cementation techniques for these restorations.

Ideal properties

To achieve favorable treatment outcomes, semi-permanent restorations should have the similar characteristics to the provisional restorations[4,5], which can be remained for the extended period of time. It could also be considered that long-term provisional crowns should have equivalent properties to those of permanent materials.[3] Below are the desired properties of the semi-permanent restorations;

1. Good marginal adaption; adapts nicely to the tooth surface and matrix
2. Adequate retention and resistance to dislodgment due to the normal masticatory function
3. Strong, durable, and hard
4. Low thermal conductivity
5. Nonirritating to pulp and other tissues; low exothermicity
6. Nonporous and dimensionally stable
7. Comfortable
8. Esthetically acceptable for the shade selection; translucent tooth-like appearance
9. High color stability
10. Physiologic contours and embrasures
11. Easy to fabricate, reline, repair, and to mix and load in the matrix; relatively short setting time
12. Physiologic occlusion
13. Conductive to routine oral home-care cleaning procedures
14. Can be highly polished with plaque- and stain-resistant surfaces after finishing
15. Easy to remove and re-cement by dentists
16. Relatively inexpensive
17. Low incidence of localized allergic reactions

Conventional provisional restorative materials

Acrylic resins

PMMA was initially introduced around 1940[6] and has remained as one of the the most frequently used materials for the fabrication of provisional restorations.[7,8]

Plant *et al.,*[9] showed that the increased intrapulpal temperature associated with the polymerization of methyl methacrylate materials could be 5 times higher compared to which associated with the normal consumption of thermally hot liquid. However, several studies indicate that PMMA is preferred when provisional restorations are made by indirect techniques.[7,10]

PEMA, introduced in the 1960s,[11] has both advantages and disadvantages compared to methyl methacrylate. Osman *et al.,*[12] showed that ethyl methacrylate material has the highest value of fracture resistance compared to methyl methacrylate and bis-acryl materials. Therefore, ethyl methacrylate may be a better selection for direct provisional prosthesis fabrication[5] and is more appropriate for short-term usage relatively to methyl methacrylate.[13,14] Two other chemically similar materials, vinyl-ethyl and butyl methacrylate, also exhibit similar clinical behavior compared to PEMA.

Composite resin

Composite provisional materials are at least composed of two main chemical ingredients. Most of these materials are made of bis-acryl resin (e.g. dimethacrylate bis-GMA, urethane resins, or resin containing at least 2 acrylic groups in the monomer).[15] When this resin is combined with an inorganic radiopaque fillers, it can be utilized as a provisional material similarly to restorative materials. In contrast to PMMA, Bis-acryl composite resins contain divinyl methacrylate monomers and filler particles. Hence, the polymerization shrinkage and exothermic release may be minimized, while color stability may be increased compared to PMMA. Moreover, it also has superior abrasion resistance and esthetics, as well as, less marginal misfit and free monomer elution.[16] These materials are available in several forms including autopolymerized, dual-polymerized, or visible light-polymerized forms. Most composite materials are currently consist of an auto-mix delivery system which is fast and easy to use with less air entrapment; however, comes with higher costs.[16,17] While bis-acryl materials are compatible with other composite materials, they are difficult to manipulate for repair and addition.[5,18]

In the 1980s, visible light polymerized (VLC) materials were introduced,[11] they require the addition of urethane dimethacrylate (UDMA), a resin whose polymerization is catalyzed by visible light and a camphoroquinone/amine photo initiator.[19,20] To improve physical properties such as reduced polymerization shrinkage, these materials typically include fillers such as microfine silica.[21] Unlike methacrylate resins, they do not produce residual free monomers after polymerization, which explains why they exhibit significantly decreased tissue toxicity relative to methacrylate resins.[22] Furthermore, Haddix[23] claimed that these materials can be used to fabricate provisional restorations with the same quality as heat-polymerized, laboratory-processed restorations, but in less time and at a lower cost. Dual-polymerized composite materials generally incorporate both auto-polymerized bis-acryl and light-polymerized urethane dimethacrylate resins in various ratios depending on the products.

Strengthening the provisional materials

Most of resins used for provisional restorations are fragile. Repairing and replacing fractured provisional restorations are concerns for both clinicians and patients because of the increased expense and time involved. Physical properties including strength, density, and hardness may predict the longevity of provisional restorations.[4] Several approaches were developed to overcome these issues aiming to convert conventional provisional materials into semi-permanent restorations.

Heat polymerization

Heat polymerization of acrylic resin materials can be used when the the increased strength and longevity of provisional restorations are required.[4] Fabrication with heat polymerization and indirect laboratory technique results in acrylic resin materials with higher density, strength, wear-resistant, color stability, and resistant to fracture compared to their autopolymerizing counterparts.[24] Chee *et al.,*[25] studied the effect of chilled monomer on the working time of 3 different autopolymerizing acrylic resins. Even though the working and setting periods were increased by up to 4 minutes, the transverse strength of the products was reduced by 17% when cold monomers were used.

Metal reinforcing structure

Hazelton and Brudvik[26] reported the benefits of stainless steel orthodontic band material adapted around abutment teeth. It can also be welded and fitted inside acrylic resin shell crowns to reinforce autopolymerizing

acrylic resin materials.[25] The increased rigidity obtained by this technique reduce the fracture rate of the materials. In addition, Galindo *et al.,*[24] used cast metal substructure with metal beadings to reinforce heat-processed provisional restoration. Although there was no chemical surface treatment on metal substructure required in both studies, the application to base metal alloys of metal conditioners containing functional monomers, such as 4-methacryloyloxyethyl trimellitate anhydride (4-META) and 10-methacryloyloxydecyl dihydrogen phosphate (MDP), significantly increased the bond strengths of a denture base resin to the titanium alloys and Co-Cr alloy substructure.[27] The reduction in flexure by these techniques prevents the loss of temporary cement's retention leading to less dental caries on the abutment teeth and loss of the provisional restoration.

Fiber reinforcement

Various materials have been used for fiber reinforcement, for instance, metal, glass, sapphire, Kevlar®, polyester, and rigid polyethylene. However, most of these materials fail to improve resin strength[4], therefore, more proper materials for this purpose are much required. Carbon fibers have been shown to massively increase the flexural strength of polymers,[28] however, their black color limits their use for provisional restorations due to the esthetic concern.[29] In addition, polyethylene fibers have been studied. Nevertheless, they did not enhance transverse strength in the absence of surface treatment because of the inadequate adhesion between the fibers and the polymer matrix.[30] However, surface treatment by plasma can increase the strength of polyethylene fibers.[31] Indeed, Samadzadeh *et al.,*[32] showed that the fracture strength was improved in bis-acryl materials with plasma treated woven polyethylene fiber (Ribbond® (Ribbond, Seattle, WA, USA)). Plasma treatment has been shown to improve the physical and mechanical properties of provisional restoration materials. Plasma is created by exciting gas molecules with an electrical energy source. During the activation, electrons are ejected from the molecules resulting in extremely reactive disassociated molecules. The removal of hydrogen atoms from the polymer backbone and their replacement with polar groups is the key mechanism of polymer surface modification. This improves the reactivity of the resin matrix and promotes excellent adherence.[33] Although the Ribbond® fibers did not improve the fracture strength of PMMA prosthesis, they could prevent advanced catastrophic fracture. As repairing and/or remaking provisional restorations can be very time-consuming, the increased strength of the PMMA with these fibers can reduce clinical failures of provisional fixed partial dentures. Additionally, these fibers have a superior esthetic property which can be beneficial in the restorations in the anterior region because the fibers become invisible when integrated into the PMMA.[31]

Silanized glass fibers have also been used for fiber reinforcement due to their strong adherence to the polymer matrix, outstanding esthetic quality, and enhanced strength of the resin composite. The silane treatment can be done in the dental office by soaking the glass fibers in a silane coupling agent for at least half an hour before usage.[34]

Resin matrix modification

Zuccari *et al.*[35,36] studied solutions to produce a resin matrix with increased strength by reducing crack propagation. They reported that adding admixed zirconium oxide granules to unfilled methyl methacrylate resin enhanced modulus of elasticity, transverse strength, toughness, and hardness drastically, even though the water sorption had a deleterious effect on mechanical properties over time.

Semi-permanent restoration materials

Several semi-permanent restorative materials have been introduced in recent years, with the manufacturer claiming that these products can last for months or years in the oral cavity. By their fabrication techniques, these materials can be categorized into 2 groups: direct and indirect restorations.

Direct restoration

The stainless steel crowns (SSC) are prefabricated metal crown restoration which consist of various sizes and can be adapted to each individual tooth. While they have been used routinely in primary teeth, the success rate of these materials in semi-permanent restorations can be ensured by if managed properly. Though the use of SSC as full coronal restorations in the permanent teeth has largely been overlooked[37], it is the most conservative full coronal coverage restoration in an incompletely erupted permanent molar with large pulp spaces with the

minimal tooth preparation required to seat the crown. Tooth preparation and crown placement are similar to SSC in primary molars; however, the short clinical crown height in immature permanent molars may result in the instability of intracoronal restorations. Nevertheless, because of their ability to be trimmed and crimped, SSC can be placed subgingivally in these teeth with an acceptable retention. They do not disturb further tooth eruption and are enable for the placement of a lab-fabricated complete coronal restoration in the future if needed.[37] According to Discepolo and Sultan,[38] SSC satisfactorily perform as provisional restorations with an average of 45.18 months of the service period. However, another study stated that these crowns are more difficult to adapt to a conventionally prepared mature permanent tooth.[17] Another disadvantage of the SSC restorations include impaction of the adjacent teeth, and periodontal defects which might lead to long-term consequences.[38] Furthermore, hypersensitivity to nickel-based restorative materials has been observed in SSC materials.[39] Thus, proper case selection and frequent follow-up are important in SSC semi-permanent restorations.

For the novel composite resin materials, 3M™ has introduced Protemp™ Crown (3M ESPE, Seefeld, Germany)[3], which was claimed to be the world's first preformed, malleable temporary crown. Protemp™ Crown materials mimic wax and can be simply carved and reshaped with a composite instrument, making them malleable and adaptable to the prepared teeth before light curing with comparable properties to resin composite materials. A combination of a unique crystalline resin system and highly interacting aggregated inorganic fillers are used in Protemp™ Crown. As a result, the material possesses a 3-dimensional, physically crosslinked structure. Light-activated curing is another feature which enables the clinicians to control the setting of the material. This light-curable resin is composed of bis-GMA and a functionalized dimethacrylate resin. Physical strength, radiopacity, and wear resistance are provided by silanated zirconia-silica and fumed silica fillers. The filler contains approximately 78 percent silanated inorganic filler by weight, with an average particle size of 0.6 micrometers. Protemp™ Crown also contains pigments and is available in various sizes for maxillary and mandibular molars, premolars, and canines making it feasible to perform on most teeth promptly and successfully.

In addition to 3M™ Protemp™ Crown, DMG has launched LuxaCrown (DMG America, Ridgefield Park, NJ, USA)[40-42], a self-curing bis-acryl composite material for the chair-side fabrication of semi-permanent crowns and bridges. It can be cemented with either permanent or temporary luting cement and is designed to last up to five years. LuxaCrown is composed of a matrix of multifunctional methacrylates, catalysts, stabilizers, and additives with a 0.02-1.5 µm glass filler particle (46 wt% = 26 vol%). Importantly, it is free of methyl methacrylate.[41] LuxaCrown also exhibits a natural appearance, great polishability, remarkable color stability, plaque reduction, superior fracture toughness, and wear properties similarly to the enamel.[40-42]

Indirect restoration

The visible light polymerized resin, such as SR Adoro® (Ivoclar vivadent, Schaan, Liechtenstein) which is manufactured by Ivoclar Vivadent is one of the commonly used materials in indirect restorations. SR Adoro® is the micro-fill composite material that possesses the UDMA matrix, the component well-known for its toughness which is higher than that of its first generation and the frequently-used bis-GMA.[43]

Nowadays, computer-aided design and manufacturing (CAD/CAM) technologies have led to major improvements in dentistry[44] and have increasingly gained attention from many clinicians. Compared to the traditional fabrication processes, CAD-CAM subtractive technologies create dependable restorations with the exact dimensions while reducing the production time and labor.[44] For PMMA material, CAD/CAM exhibits significant improvement in flexural strength, impact strength, and flexural modulus when compared to the conventional heat-cured PMMA.[45] The subtractive manufacturing technique was often thought to be synonymous with CAM; a PMMA block is milled, ground, drilled, turned, or polished into a desired shape and dimension in this procedure. While having several advantages, subtractive manufacturing has the procedural and environmental disadvantages of restricted surface resolution. The milling process can result in up to 90% of material loss[46] and generate both surface and sub-surface machining defects.[44] Furthermore, the subtractive approach can generate only a limited number of restorations in each machining cycle and cannot produce advanced or com-

plicated designs. Additionally, the instruments can be worn after a certain of cycles which might lead to several problems. In contrast to the subtractive approach, additive procedure can save materials and generate more complex shapes resulting in an increased popularity in the dentistry industry.[44,46]

In the recent study comparing 3D printing and milling technologies, provisional crowns produced by 3D printing generated superior intaglio surface trueness with uniformity than milled crowns.[47] Thus, many clinicians are currently more interested in 3D-printed provisional crowns due to the numerous advantages including reduced manufacture cost and time with higher accuracy and predictable results.

Cementation for semi-permanent restoration

To prevent contamination and bacterial penetration, luting agents must have high mechanical properties, low solubility, and strong adhesion to teeth.[48] to ensure that the restoration and prepared tooth are properly sealed[49] and to prevent marginal leakage and pulpal irritation.[48,49] For temporary restorations, various luting materials are used including calcium hydroxide, zinc oxide eugenol, as well as, zinc oxide non-eugenol.[48] However, all of these have weak mechanical qualities which are prone to degrade over time. This can have a detrimental impact on marginal leakage, While it is easier to remove the provisional restorations cemented with these materials from teeth, marginal leakage is likely to be observed.[48]

For the semi-permanent restoration, Spear[50] suggested two types of cement. First, reinforced zinc oxide eugenol because of its sealing property, sensitivity protection, ease of removal, and palliative effect on the pulp.[51] When using reinforced zinc oxide eugenol, the restorations must be thoroughly polished and patients have to be followed up every 8 to 12 weeks. Zinc oxide eugenol require a complex acid-base reaction to form cement which is different from other aqueous dental cement that requires the presence of an accelerator (often acetic acid). Exposure to water speeds up the setting time in the latter. Although fully-set zinc oxide eugenol has an excellent sealing ability, the physical properties (compressive strength, tensile strength, solubility, etc.) are still compromised leading to remarkable creep and flow under pressure. For these reasons, zinc oxide eugenol is not commonly used for luting definitive restorations.[52] In the late 1950s, 2-ethoxybenzoic acid (EBA) was added to zinc oxide eugenol cement to improve its properties; the example of this product is SuperEBA® (Keystone Industries, Gibbstown, NJ, USA). However, the presence of EBA may have a negative impact on the film thickness and solubility.[51]

The second cement that Spear[50] suggested is resin-modified glass ionomer (RMGI) which is indicated for patients who require one to two years of orthodontic treatments. This cement remarkably eliminates the possibility of caries, leakage, sensitivity, and loosening, but the modification and/or renewal of the provisional restorations is required when the orthodontic treatment is done. RMGI is a hybrid material combining water-soluble polymers or polymerizable resins with conventional cement The examples of RMGI products are GC Fuji Plus® (GC America, Chicago IL, USA), 3M RelyX™ Luting Cement (3M ESPE, Seefeld, Germany) and Dyract® Cem (DENTSPLY DeTrey, Konstanz, Germany). RMGI was created in the 1980s attempting to overcome the two important weaknesses of conventional glass-ionomer cement including low early strength and high solubility. Upon two separate reactions occur: 1) the resin phase which polymerizes quickly (either by chemical or light initiation) and 2) the glass ionomer phase which proceeds slowly toward normal maturation via an acid-base reaction over an extended period of time. When compared to the conventional glass ionomers (GI), fully-set RMGI cement offer superior physical and mechanical properties. A very important characteristic which is superior to GI is that RMGI has the cariostatic potential as a consequence of fluoride release, as well as, the ability to induce remineralization. Although RMGI has higher strength and lower early solubility, loss of adhesion to tooth structure and a propensity for dimensional change due to water uptake during the resin phase can be found.[52]

Burke[3] suggested using self-adhesive resin cement for the resin-based crown material used as a semi-permanent restoration. Though future studies are needed, it is believed that the self-adhesive resin luting cement bonds to the resin-based crown, hence, maximizing its retention. However, some do not recommend GI and resin-based adhesive cements to retain provisional restorations because their bond to the prepared tooth surface is too strong making the removal of the provisional restoration, cleaning of the tooth surface, and cementation of the final

restoration more difficult.[53]

Conclusions

Based on the current literature, numerous advantages of semi-permanent restoration materials are suggested and new approaches to strengthen these materials are also proposed. As strengthening the conventional provisional materials can be expensive, inconvenient, and time-consuming in some cases, CAD/CAM technologies and novel chair-side fabricated composite resin materials have been introduced to overcome these limitations. Table 1 provides a summary of compositions, fabrication techniques, advantages and limitations of semi-permanent restoration materials. Furthermore, some of the ideal properties described earlier were listed in the advantages of each material in this table.

Additionally, cementation is also a crucial step contributing to the success of the semi-permanent restorations. The cementation procedures and materials of choice are determined by the duration of the treatment and restoration lifetime. RMGI and self-adhesive resin cements are excellent choices for 1-2 years of orthodontic therapy due to their high retention, while reinforced zinc oxide eugenol cement is preferred for a shorter treatment time. Therefore, a proper selection of restoration and cementation materials is very crucial as it can enormously contribute to the success of the treatment with semi-permanent restorations.

Table1: A summary of compositions, fabrication techniques, advantages and limitations of semi-permanent restoration materials

Semi-permanent restoration materials	Fabrication techniques	Main compositions	Advantages	Limitations
Stainless-steel crown	Direct restoration	Nickel-based metal	• Long-term success for primary teeth • Various sizes and shapes • Mostly conservative full coronal coverage for erupting permanent molars	• Difficult to adapt to mature permanent teeth leading to food impaction, periodontal defect, and hypersensitivity
Protemp™ Crown	Direct restoration	Bis-Acryl	• Chairside carving and adaptation • Various sizes and shapes • Equivalent physical properties to resin composite materials • Light-curable	• More chair time and clinician's skills are needed compared to the indirect restoration
LuxaCrown	Direct restoration	Bis-Acryl	• Long-lasting (up to 5 years) • High esthetics • Excellent polishability • Exceptional color stability • Plaque reduction • Improved fracture toughness and wear resistance similar to the enamel	• More chair time and clinician's skills are needed compared to the indirect restoration
Milled PMMA crown	Indirect restoration	PMMA	• Superior flexural and impact strength, and flexural modulus compared to the conventional heat-cured PMMA	• Higher cost than the direct restoration • Reduced surface resolution • Material waste and machine errors
3D-printed PMMA crown	Indirect restoration	PMMA	• Less material waste and more uniformity when constructing advance designs • Superior intaglio surface trueness compared to milled crowns	• Higher cost than the direct restoration

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The Effect of Heat-polymerizing Method on Color Stability of Acrylic and Composite Resin Dentrue Teeth

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Abstract

Objectives: The purpose of this study was to investigate the color stability of acrylic and composite denture teeth after heat-polymerization method.

Methods: Three different brands of acrylic denture teeth: Livera Alpha (LA), Yamahashi (YA) and Major Dent (MA) and 2 different brands of composite denture teeth: Yamahashi PX (YC) and Endura (EC) were tested. Ten maxillary central incisors from each group were pressed onto putty-type polyvinyl siloxane in order to measure color in the same area of denture teeth. Color, at cervical third and incisal third, was recorded by spectrophotometer in CIE L*a*b system. All specimens were undergone heat-polymerization of heat-curing acrylic resin. After flask cooling for 24 hours, the specimens were removed. The color measurement was performed at the same area of each specimen. Color differences (ΔE) was calculated. A ΔE of ≤3.3 was considered clinically acceptable. The data were evaluated by 3-way repeated-measures ANOVA and Tukey HSD test (α =0.05).

Results: The ΔE of LA, YA, EC, MA and YC at incisal third were 4.41±0.56, 2.45±0.60, 0.76±0.57, 0.75±0.24 and 0.63±0.24 respectively. At cervical third, the ΔE of LA, YA, EC, MA and YC were 4.59±1.26, 2.44±1.08, 0.59±0.36, 0.81±0.61 and 1.22±0.78 respectively. The highest ΔE values were found in LA. These values were significantly higher than those obtained from other brands (p<0.05) and beyond clinically acceptable level.

Conclusions: After heat-polymerization, the color of LA changed significantly at both incisal and cervical areas. On the other hand, color stability of YA, EC, MA and YC were clinically acceptable.

Keywords: acrylic denture teeth, color stability, composite denture teeth, heat-curing polymerization

Introduction

The matching color between natural teeth and artificial denture teeth plays an important role in esthetics of removable dental prosthesis and affects patient's quality of life.[1,2] Color stability is a crucial physical property in order to maintain color matching.[3] Both intrinsic and extrinsic factors can cause color change of denture teeth.[4] Intrinsic factors are the type and composition of material.[5] Extrinsic factors are physical and chemical conditions, such as thermal change and denture cleansing agent.[4-6]

Various types of denture teeth are available in the market which are acrylic resin, composite resin and porcelain. Among these 3 types, acrylic resin denture teeth are widely used due to excellent chemical bond to denture base.[7] Composite resin denture teeth are gaining their popularity because of their esthetics and improved physical properties.[8,9] Although porcelain denture teeth exhibit the highest wear resistance and color stability compared to other artificial teeth, they has poor chemical bond to denture base.[5]

There are many studies investigated the color stability of denture teeth immersed in various types of chemical agents.[1-3] Systematic review by Tieh *et al.*, concluded that the degree of discoloration of denture teeth after immersion was time-dependent and the largest extent was found in initial phase.[2] An *In vivo* study by Rosentritt *et al*., found that composite resin veneers significantly exhibited higher color changes compare to acrylic resin denture teeth.[8] However, the discolorations of both materials were clinically accepted.

In conventional denture fabrication, polymerization process of denture base is inevitable. There is only 1 study about the color stability of denture teeth after the polymerization process.[5] This study showed that among 10 different brands of acrylic resin denture teeth, Biotone IPN and SR Vivodent PE teeth presented the greatest change in color; Mondial 6, Biolux, and Trilux teeth presented the least change in color. However, all ΔE values are within acceptable clinical limits for all brands.

Due to the lack of the study about color stability of denture teeth after polymerization process of denture base. The purpose of this study was to investigate the effect of heat-polymerization method on color stability of denture artificial teeth. Three different brands of acrylic artificial teeth and 2 different brands of composite artificial teeth that were commonly used in Thailand were investigated in this study. The null hypothesis was that the color stability of acrylic and composite resin artificial teeth was not affected by heat-polymerization method.

Materials and Methods

Three different brands of acrylic resin denture teeth; Livera Alpha (LA), Yamahashi (YA) and Major Dent (MA), and 2 different brands of composite resin denture teeth; Yamahashi PX (YC) and Endura (EC), were included in this study (Table 1). Total of 50 maxillary central incisors (10 from each group) were evaluated. All specimens were subjected to heat-polymerization method. Color measurements were performed at 4 timepoints in order to investigate the effect of heat-polymerization method on color stability of denture artificial teeth.

Heat-polymerization method

All specimens were put in a brass flask used for denture fabrication without embedding in plaster. The flask was placed in a water bath (KaVo EWL 5518, KaVo Elektrotechnishes Werk GmbH, Warthausen, Germany). Then the specimens were subjected to heat-polymerization according to manufacturer's instruction for heat-curing acrylic resin: boiling temperature was divided into 2 cycles; 80°C for 4.5 hours then 95°C for 5.5 hours. After flask cooling for 24 hours, the specimens were removed, washed with distilled water, and dried with paper.

Color measurement

Prior to heat-polymerization process, each specimen was pressed onto putty-type polyvinyl siloxane in order to measure color change in the same areas of each artificial tooth. Color measurement was performed at the center of cervical third and incisal third of each specimen and recorded at 4 timepoints: before heat-polymerization as baseline (B), 1 day (D1), 15 days (D15) and 30 days (D30) after the polymerization process by spectrophotometer (UltraScan-Pro Hunterlab® Hunterlab, VA, USA) in Commission Internationale de l'E´clairage (CIE) system.[10,11]

Visual color test

To determine clinical significance, the visual color test was performed. Three female fifth-year dental students who had a theoretical knowledge of color were

randomly selected as operators. They have normal vision tested by Snellen's Eye Chart[12] and they don't have color vision anomalies tested by Ishihara's color charts.[13] Then they were asked to compare the color of 50 denture teeth to un-treated denture teeth of each group at day 1, day 15 and day 30 after heat polymerization. All comparisons were performed against a white background for 5 seconds under a 15 W cool white fluorescent strip lamp. They marked the score 0 or score1 for each denture tooth when the color was not changed or the color was changed respectively (maximum=10 for each brand).

Statistical analysis

The denture teeth color were measured by using the CIE L* a* b* system then calculates color differences (ΔE) by using the formula : $\Delta E = (\Delta L^2+\Delta a^2+\Delta b^2)^{½}$. Color differences (ΔE) was calculated. A ΔE of ≤3.3 was considered clinically acceptable.[14,15] The effect of type of denture teeth, position and time after the polymerization process on color stability (interactions among these factors) was analyzed by 3-way repeated-measures ANOVA and the Tukey HSD test (α =0.05).

Results

Table 2 showed the means and standard deviations of ΔE values of all brands both incisal and cervical areas at 1 day, 15 days and 30 days after the heat-polymerization process. The ΔE at day 1 of LA, YA, EC, MA and YC at incisal third were 4.41±0.56, 2.45±0.60, 0.76±0.57, 0.75±0.24 and 0.63±0.24 respectively. At cervical third, the ΔE of LA, YA, EC, MA and YC were 4.59±1.26, 2.44±1.08, 0.59±0.36, 0.81±0.61 and 1.22±0.78 respectively. The highest ΔE values of LA were obtained; these values were significantly higher than those obtained from other brands (p<0.05) and beyond clinical acceptable level, whereas the other brands were considered clinically acceptable (ΔE ≤ 3.3) for both incisal and cervical areas. Resulting from the visual color test by 3 observers, the mean values(SDs) of LA artificial teeth which had color changed after heat polymerization was 7.67±0.57, 7.33±0.57, 8.33±1.15 at day 1, day 15 and day 30 respectively. However, the other brands had the number of color-changed denture teeth less than 5 (Table 3).

Considering the time after the polymerization process (Day 1, Day 15 and Day 30), regardless of brands and position of denture teeth, there were not statistically different. The same tendency was noticed for each position of denture teeth (incisal and cervical areas) (Table 4). The interaction between the brand of denture teeth and the position of denture teeth was statistically significant (p<0.001) (Table 4) and the interaction among the brand of denture teeth, position and time after the polymerization process was also statistically significant (p=0.001).

Table 1: Denture teeth used in this study

Brand	Code	Shade	Materials	Manufacturers
Livera Alpha	LA	A3.5	acrylic resin	SHOFU INC., Japan
Yamahashi	YA	A3.5	acrylic resin	Yamahashi Dental MFG., Co., Japan
Major Dent	MA	2L	acrylic resin	Major Prodotti Dentari S.p.A., Italy
Yamahashi PX	YC	A3.5	composite resin	Yamahashi Dental MFG., Co., Japan
Endura	EC	A3.5	composite resin	SHOFU INC., Japan

Table 2: Mean values(SDs) of color differences (ΔE) in denture teeth

	Incisal area			Cervical area		
	Day 1	Day 15	Day 30	Day 1	Day 15	Day 30
Livera Alpha (LA)	4.41(0.56)^a	4.35(0.47)^a	4.40(0.64)^a	4.59(1.26)^a	4.37(1.06)^a	3.68(0.97)^a
Yamahashi (YA)	2.45(0.60)^b	3.26(0.56)^b	3.17(0.40)^b	2.44(1.08)^b	1.17(0.66)^b	1.62(0.76)^b
Major Dent (MA)	0.75(0.24)^b	0.54(0.43)^b	0.81(0.61)^b	0.81(0.60)^b	1.19(0.52)^b	1.20(0.78)^b
Yamahashi PX (YC)	0.63(0.24)^b	0.57(0.45)^b	0.82(0.46)^b	1.22(0.78)^b	1.57(0.75)^b	1.11(1.05)^b
Endura (EC)	0.76(0.57)^b	1.15(0.35)^b	1.40(1.29)^b	0.59(0.36)^b	1.13(0.65)^b	0.63(0.38)^b

Different lowercase letters within column denote group differences that are statistically significant (p<0.05).

Table 3: Mean values (SDs) of color change scores by 3 observers

Brand	Day 1	Day 15	Day 30
Livera (LA)	7.67(0.57)[a]	7.33(0.57)[a]	8.33(1.15)[a]
Yamahashi (YA)	4.33(0.57)[b]	3.67(1.15)[b]	3.67(0.57)[b]
Major Dent (MA)	2.00(1.00)[b]	1.00(1.00)[b]	1.33(0.57)[b]
Yamahashi PX (YC)	1.67(0.57)[b]	1.33(0.57)[b]	1.00(0.00)[b]
Endura (EC)	1.00(1.00)[b]	1.00(0.00)[b]	0.67(0.57)[b]

Different lowercase letters within column denote group differences that are statistically significant ($p<0.05$)

Table 4: Results of 3-way repeated-measures ANOVA

Source	df	SS	MS	F	*p*
Brands	4	524.560	131.140	261.588	<0.001*
Position	1	1.541	1.541	3.074	0.081
Time	2	0.233	0.116	0.232	0.793
Brands x Position	4	30.328	7.582	15.124	<0.001*
Brands x Time	8	5.677	0.710	1.416	0.190
Brands x Position x Time	8	13.035	1.629	3.250	0.001*

*$p<0.05$ denotes statistically significant difference

Discussion

In clinical situation, we occasionally encountered the problem that the color of denture teeth in finished denture mismatched with adjacent nature teeth. Therefore we would like to identify the cause of this problem. In this present study, we investigated the color stability of 3 brands of acrylic denture teeth and 2 brands of composite resin teeth after heat-polymerization method. The null hypothesis of this study was partially accepted as the color stability of acrylic resin denture teeth was affected by heat-polymerization method. However, there was no significant effect on color stability of composite resin denture teeth.

The previous study compared the effects on color stability of heat polymerization to those of microwave polymerization.[5] All 10 brands of acrylic resin teeth had ΔE less than 3.3 in both groups of polymerization, indicating that the color change would likely not be clinically perceptible. Nevertheless, not only the acrylic denture teeth tested in their study are not commonly available in Thailand, but also composite resin denture teeth are not yet investigated. Therefore, we would like to conduct similar investigation with the acrylic and composite resin denture teeth that are commonly used in Thailand.

The measurement of artificial teeth color in this research was measured by spectrophotometer and observers using visual color comparisons. Considering the results between the visual evaluation and spectrophotometer, LA were marked the highest scores in visual evaluation corresponding with the highest ΔE value which was measured by spectrophotometer. These results suggested that the color change in LA is clinically perceptible and unacceptable. The ΔE of other brands (YA, MA, YC, EC) was lower than 3.3 both incisal and cervical areas, so most observers could not detect the color difference between denture teeth and marked low color change scores for them (Table 3). However, the visual comparison could not detect the little amount of color change. In addition, it could lead bias from variables namely light conditions, experience, age, and fatigue of the human eyes.[16] Therefore, spectrophotometer was used instead of visual evaluation in order to eliminate subjective interpretation.[17,18]

To avoid errors from the operation of the spectrophotometers, the machine was calibrated before color measurement of each group. After that, we measured the color values of the control group and compared with the previous results. Apart from the operation of the spectrophotometer, the position of the specimen could influence

the measurement of color. To ensure the maintenance of each denture tooth in the same place during all measurements, a silicone rubber tool was created specifically for each brand.

Thickness and smoothness of the tooth surface may influence its color. The lightness of the resin increased as thickness decreased.[19] However, no thickness and smoothness was altered in this present study. Previous study demonstrated that the color stability of composite resin veneers and acrylic resin teeth was observed.[8] The authors observed that the additional reagents in acrylic resin teeth, dibenzoyl peroxide, which remained after polymerization may affect color stability. LA teeth may present more levels of dibenzoyl peroxide than the other brands. According to the study of Guler *et al.*, The acrylic resin was usually used different monomers in their liquids such as MMA (methyl methacrylate), HDMA (hexamethylene glycol dimethacrylate), HEMA (2-hydroxy ethyl methacrylate).[3] Hersek *et al.*, and Lazzetti *et al.*, concluded that hydrophilic materials presented a greater color change than hydrophobic materials.[20] Therefore, LA teeth may contain more HEMA, which has more hydrophilic than HDMA and MMA, than other acrylic teeth brands. For YC and EC teeth, the factors which can affect the change in color of resin composite are chemical differences among the resin components, both filler type and concentration and polymerization time during the processing of the heat-curing material.[8]

Several studies found that the higher chromatic or darker shades had larger color changes.[8,21,22] To eliminate this factor, shade A3.5 was selected in our study. For MA, shade 2L which was similar to shade A3.5 of the other brands was selected. In general, cervical area of denture teeth would have higher pigments or chroma than incisal area. Therefore, we measured the color changes at incisal third and cervical third in each individual denture teeth. The results showed that there was no significant difference between these areas.

In this present study, we investigated color stability at 1, 15, 30 days after heat polymerization. The results by spectrophotometer and observers showed no significant difference among different time periods. These results suggested that color changes caused by heat-polymerization method did not increase by time and was irreversible.

The limitation of this study was the sample size. The small sample size decreases the accuracy to represent the entire population. This study did not completely mimic all denture fabrication procedures as only teeth were submitted to a simulation of polymerization without utilizing the acrylic resin as a denture base. Thus, further studies should evaluate the impact of acrylic resin denture base on its color stability of acrylic resin along with the denture teeth.

Conclusions

Within the limitation of this study, the following conclusions could be drawn:

1. Livera Alpha acrylic resin denture teeth had the least color stability and was clinically unacceptable.
2. The ΔE values of Yamahashi and Major Dent acrylic resin denture teeth were beyond clinical acceptable level for both incisal and cervical areas. The same resulted was found in Yamahashi PX and Endura composite resin denture teeth.
3. Considering the position of artificial teeth (cervical area and incisal areas) and the time after the polymerization process, color change was not statistically different in each position and time.

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Conflicts of interest

The authors declare no conflicts of interest.

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Comparison of Patients' Satisfaction Between 2-dimensional and 3-dimensional Digital Smile Simulation

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Abstract

Objectives: To compare 2-dimensional (2D) and 3-dimensional (3D) smile simulation techniques from the perspective of patient preferences in comfort during data collection and the simulation outcome.

Methods: Twenty subjects (10 males and 10 females) with no experience with smile simulation participated in this study. Data collection was performed by using a DSLR camera (Nikon, Tokyo, Japan) for dentofacial photography, an intraoral scanner (3-Shape, Copenhagen, Denmark) for an oral scanning file, and a tablet device (iPad, Apple, CA, USA) for smile video recording. The subjects' perceptions of comfort towards each data collection process were evaluated using a standardized questionnaire. A week later, both 2D and 3D smile simulation outcomes were presented to participants, and subjects' preferences toward the simulation outcomes were evaluated. Statistical analyses were performed with Wilcoxon Signed Ranks Test and the one-sample chi-square test.

Results: A statistical implication presented the significant difference between 2D and 3D subjects' satisfaction in terms of time consumption for data gathering. The results showed that 90% of subjects were satisfied with 2D simulation rather than 3D simulation due to time (p=0.002). For satisfaction of the simulation outcome, there was a significant difference in the statistical implication (p<0.05). Even though preference and recommendation were significantly different factors, the subjects' overall satisfaction levels were not significantly different (p=0.74).

Conclusions: Although the satisfaction of recruited individuals in the 2D simulation was higher than that in the 3D simulation during the data collection process, there was no difference in patients' preferences between the 2D and 3D outcomes.

Keywords: digital smile simulation, patient comfort, patient preference, satisfaction

Introduction

Facial attractiveness is a significant influence in one's overall psychological and social health, and an appealing smile is a necessary component of the psychological well-being.[1,2] The number of people seeking the help of dentists in order to improve their smile is rising.[3] Skeletal systems, alveolar casing, teeth, and the underlying soft tissue covering all work together intricately to create the appearance of a beautiful smile and dental esthetics. The total effect of these factors seems to be what humans perceive to be a person's smile. Regularly, a person's success in social situations can be gauged by observing their smile, which reveals their ability to convey various emotions by the shape and movement of their teeth and lips.[4-6]

Traditionally, dentists have only used verbal explanations of treatment options, occasionally supplemented with pictures of patients who had comparable problems handled. Presenting a patient with a design wax-up is another classic method for informing them of treatment options.[6] However, modern computer design software has advanced for an effective demonstration to patients the range of options available to them for improving their smiles. Numerous conventional dental procedures can be benefited from the use of digital aids, which have the potential to improve esthetic outcomes and produce healthy, natural, beautiful, and self-confident smiles. Dental treatment planning software is becoming increasingly digital, which has the potential to strengthen diagnoses, improve communication/education, and increase treatment predictability.[7]

As a result, there is a development plan to bring a new set of tooth simulations to superimpose on patients' faces using computer applications such as PowerPoint and Photoshop. The results demonstrate the harmony between the new set of teeth, the characteristics of the lips, and the patients' face. For instance, Christian Coachman's Digital Smile Design[8] displays the design of a 2-dimension face smile that might potentially create a clear visualization, resulting expectation rather than replicated wax pattern. This method also improves communication between dentists and dental technicians.

Because most virtual diagnostic pictures are displayed in two dimensions and do not fully depict the potential changes to the extraoral appearance, the patient must review the treatment plan and outcome prior to initiating therapy. Even so, the real effects of any treatment on the patient's dental and facial appearances, particularly alterations in facial soft tissue, can be seen only at the completion of treatment. Three-dimensional virtual pretreatment diagnostics offer a viable solution for predicting tooth morphology and final position.[9] It is now possible to fulfill pretreatment evaluations on 3D reconstructions by stitching standard digital intraoral and extraoral photographs with specialized software and cloud computing to better plan the treatment for difficult dental and/or medical procedures.[8]

The majority of research focuses on the outcome and accuracy of smile simulation, as demonstrated by Delmonte's research in a systematic review of lay person's preferences for dento-gingival esthetic parameters[10] and Flores-mir, the layperson's perception of smile aesthetics in dental and facial perspectives.[11] Consequently, additional studies about patient satisfaction relative to present technological treatment are always driven by the emergence of new technologies. As an example, many studies have compared oral scanning, a relatively new technology, to the conventional functional impression approach. Research comparing 2-dimensional and 3-dimensional digital simulation in terms of patient satisfaction is still limited, but the new 3-dimensional digital simulation tends to greatly improved patient satisfaction. Moreover, DigiPro Smile (Tomorrow Smile, Bangkok, Thailand) has been launched since 2018, which simulates a 3D digital smile and correlates patient oral scanning with the 3D design. This software presented the outcome as a 3D videography to the patient for decision-making prior to definitive treatment.

Thus, the objective of this study was to analyze the difference in treatment comfort during data collection and the difference in patients' preference between 2D and 3D smile simulation outcomes. We hypothesized that there was no difference in patient comfort between 2D and 3D smile simulation, and there was no difference in patient's preference between 2D and 3D smile simulation.

Material and Methods

Clinical trial design

A cross-over design was used for this experiment. Each participant received each simulation procedure in turn. This research was registered with the Thai Clinical Trials Registry (TCTR20221206002) and received

approval from the Human Experimentation Committee at the Faculty of Dentistry, Chiang Mai University (No. 17/2020). All participants signed assent and informed consent forms to participate in the study.

Sample size calculation and participants

This study calculated sample size based on previous study by Yuzbasioglu *et al.*[12] Considered with the power of 90% at level of significance 5%, this research calculated the target population to classify into two independent group with 20 samples, allowing for a loss to drop out of 10%.

Twenty volunteers were participated by using inclusion and exclusion criteria. The inclusion criteria of this study were: 1) an age range of 18-25 years old; 2) American Society of Anesthesiologists (ASA) classification I and II; 3) good oral hygiene; 4) some smile appearance defects (mild crowding, spacing, and fracture); 5) digital friendly: and 6) literacy in the Thai language. Criteria for exclusion of this study were moderate to excessive dental anxiety, previous experience of orthodontic treatment, low lip line and smile line, Angle's classification III, loss of anterior teeth, experience with knowledge of smile design and smile simulation, craniofacial anomalies, maximum mouth opening lower than 35 mm, hyperactive gag reflex, and current oral lesion.

Questionnaire

Participants were required to complete the questionnaire on their first and second visits. Following the research objectives, a questionnaire was created to examine two aspects of patient satisfaction: the perception survey and the comparative survey. To confirm the validity of the survey questions, the questionnaire used in this study was pretested, revised, and retested before use. The suggested questionnaire was administered to three dental specialists. The finalized questionnaire after adjustments and corrections to the survey instrument, consisted of four parts in Thai language: the first was basic information and importance criteria confirmation, second was comfort during data collection, including pain, nausea, discomfort, stress, and time based on scoring and comparison of 2D and 3D simulations; the third was comparison-based simulation outcome, and the last part was an overall assessment of comfort and simulation outcome. To assess the patients' comfort, a Likert scale survey with a conventional five-level item (5 = very high, 4 = high, 3 = moderate, 2 = low, and 1 = none) was utilized. The survey included questions about the patients' opinions of simulation recommendations and preferences.

Intervention and procedure

In first visit, the patient's basic data acquisition was randomly collected and 2D image files of extraoral and intraoral photographs were taken via DSLR camera (Nikon D610, Tokyo, Japan) and mouth retractor under the same environmental, and lighting conditions by one calibrated operator (S.M.). In 3D data acquisition, a tablet device (iPad Pro 11, Apple, CA, USA) and an oral scanner (3-Shape, Copenhagen, Denmark) were used to collect the facio-dental motional video of motional smiling activities and intraoral scanning files sequentially by one calibrated operator (W.A.). Prior to this clinical trial, all operators had been repeatedly trained in their assigned roles to perform with the same duration of data collection, scanning time, and mouth retractor protocol. After image collection, those 2D image files was designed and created 2D digital smile simulation by Keynote software (iWork, Apple, CA, USA). Then, intraoral scanning files were superimposed with facio-dental motional video to generate 3D smile simulation by DigiPro Smile software (Tomorrow Smile, Bangkok, Thailand). After a week, the outcomes of 2D and 3D smile simulation (Figure 1C and 2C) were presented to all participants individually in second visit.

Statistical analysis

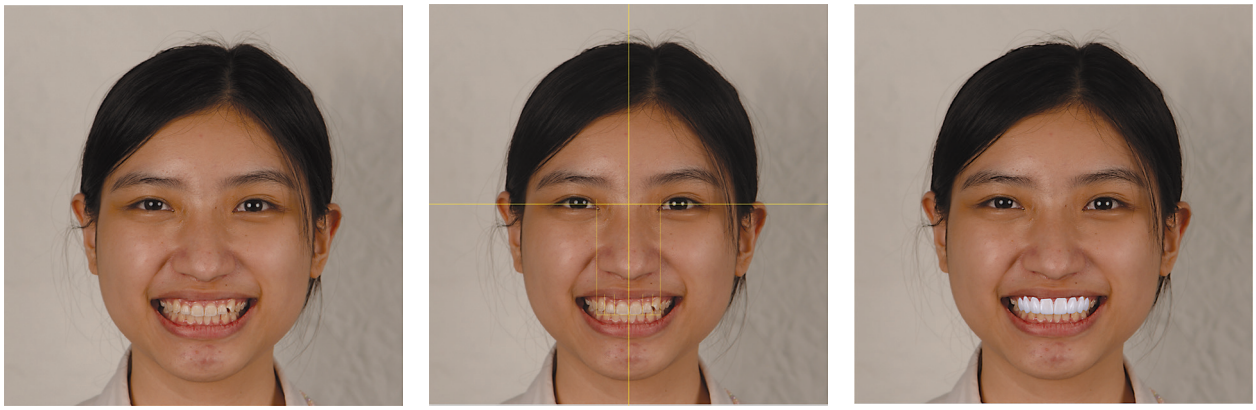
Because the assumptions of parametric statistical analysis were not met, the data were analyzed using nonparametric tests. These data were analyzed using the nonparametric Wilcoxon Signed Ranks test and one-sample chi-square with a simultaneous p value adjustment, with <0.05 as the level for statistical significance. Data analysis was performed using the SPSS 24.0 software (SPSS Inc., Chicago, IL, USA).

Results

The number of participants was 20, who matched the research's setting criteria without follow-up absences. The participants were ten males and ten females, and the age range was between 19 and 21 years. All of the participants had never experienced a smile simulation, orthodontic

Example of 2D digital smile simulation

A 2D digital smile simulation was shown in Figure 1.



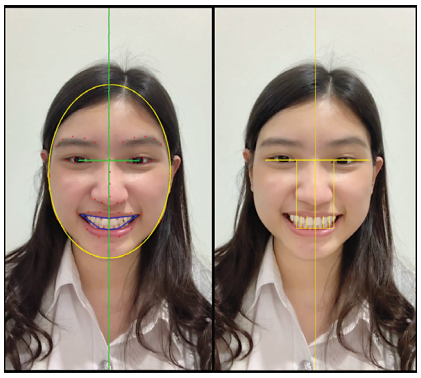
(A) Prerequisite photography (B) Simulation process (C) Outcome

Figure 1: 2D digital smile simulation. (A) Prerequisite photography, (B) Simulation process, (C) Outcome. The full frontal photographs of this volunteer were granted in the form of written consent

Example of 2D digital smile simulation

A 3D digital smile demonstration was shown in Figure 2.

(A) Prerequisite videography



(B) Simulation process. The simulation analysis procedures included the recognition of facial landmarks and the calculation of head posture.

(C) Outcome

Figure 2: 3D digital smile simulation. (A) Prerequisite videography, (B) Simulation process, (C) Outcome. The full frontal photographs of this volunteer were granted in the form of written consent

treatment, or extra-intraoral photography with a mouth retractor.

Comfort during data collection

First, the satisfaction scores for 2D, and 3D simulations based on twenty subjects and five topics were collected. Pain, nausea, discomfort, stress, and time were among the topics addressed, with frequency and percentages provided (Table 1). The answers in the questionnaire including none, low, moderate, high, and very high, however, only none, low, and moderate level responses were given by all participants to the five topics. It was found statistical analysis results that the significant difference between 2D and 3D subjects' satisfaction in terms of time consumption for data gathering (p=0.002). Notably, the result showed that more than 90% of participants were satisfied with the time consumption of data collection in 2D simulation.

In the second section, the comparison based on overall satisfaction during data collection indicated that 60% of participants were satisfied with 2D, 20% were satisfied with 3D, and 20% had no difference in overall satisfaction between the 2D and 3D systems during data collection (Table 2).

Simulation outcome

When the two simulations were compared, it was discovered that 20% were satisfied with the 2D simulation, 75% were satisfied with the 3D simulation, and only 5% were satisfied with both equally. While the comparison-based outcome in simulation system recommendation was selected by 35% of participants in 2D simulation and 60% in 3D simulation, participants recommended both 2D and 3D systems to 5% (Table 3). The outcomes of the 2D and 3D simulations showed significantly different simulation results (p<0.001) and suggestions (p<0.05).

Overall satisfaction

A comparison-based questionnaire of two simulation systems revealed that the overall satisfaction of 2D systems was 40%, whereas 3D systems were 50%, with 10% satisfied equally (Table 4). Consequently, there was no significant difference in the overall satisfaction of the simulation systems.

Discussion

The statistical analysis of this investigation revealed that there was no difference in treatment comfort throughout data collection for 2D and 3D smile simulations. The study found that the target group was equally satisfied with 2D and 3D simulations. In terms of the time required for data collection, however, 2D simulation proved to be more efficient than 3D simulation. In consequence, 90% of the target participants was satisfied with the 2D simulation. Intraoral scanning was found to be time-consuming in the 3D simulation data collection process, with participants spending more minutes than in the 2D simulation. Also, there is a learning curve for using the intraoral scanner in the dental clinic, and this must be carefully considered.[13-17]

It was agreed that there is no difference in patients' preferences between the outcomes of 2D and 3D smile simulations. In terms of smile simulation design, about 75% of the target group preferred 3D simulation over 2D simulation. The main reason was that 3D simulation presented many distinct facial angles, resulting in an accurate outcome and an efficient treatment plan. Furthermore, the 3D system facilitated patient communication. According to the findings of the Daher *et al.* study[18], the benefit of a 3D system was the ability to provide esthetic outcomes from all possible view angles, which would surely enhance the realism of digital smile simulations.

The well-known software applications are DSDApp 3D[19] (DSD, Madrid, Spain) and IvoSmile App[20] (Ivoclar Vivadent, Schaan, Liechtenstein). These 3-dimensional digital smile is a new technology development that has the potential to have a significant impact and benefit on dental clinics all over the world. The file demonstrates harmony between dental and face scanning photos or films, allowing dentists to understand more about specific treatment problems and build a more successful treatment plan. This solution is more effective than other simulation models. For example, IvoSmile App, a smile simulation software that aims to simulate real-time 3D visualization of teeth, which could potentially enhance the communication efficiency of patients.[20] Similar to Digipro Smile, IvoSmile App and DigiPro Smile simply mimics tooth alignment without modifying the shape of the teeth. The DigiPro Smile software also provides the 3D smile simulation in motion for virtualization on a mobile device. To minimize data collection errors for the smile

Table 1: Patients' comfort during data collection in 2D and 3D smile simulation process

	Scale	2D simulation		3D simulation		*p*-value
		frequency	%	frequency	%	
Pain	1 (None)	17	85	13	65	
	2 (Low)	2	10	5	25	0.190
	3 (Moderate)	1	5	2	10	
Nausea	1 (None)	19	95	19	95	
	2 (Low)	1	5	1	5	1.000
	3 (Moderate)	0	0	0	0	
Discomfort	1 (None)	12	60	8	40	
	2 (Low)	7	35	12	60	0.317
	3 (Moderate)	1	5	0	0	
Stress	1 (None)	16	80	14	70	
	2 (Low)	3	15	6	30	0.655
	3 (Moderate)	1	5	0	0	
Time	1 (None)	18	90	6	30	
	2 (Low)	1	5	8	40	0.002*
	3 (Moderate)	1	5	6	30	

The data was analyzed using the one-sample chi-square test.
*Statistically significant at $p<0.05$

Table 2: Comparison of satisfaction during data collection

	2D Simulation		3D simulation		No difference		*p*-value
	frequency	%	frequency	%	frequency	%	
Less pain	5	25	3	15	12	60	0.035*
Less nausea	7	35	0	0	13	65	0.263
Less discomfort	15	75	1	5	4	20	<0.001*
Less stress	6	30	5	25	9	45	0.522
Less time	18	90	0	0	2	10	<0.001*
Overall	12	60	4	20	4	20	0.041*

The data was analyzed using the one-sample chi-square test.
*Statistically significant at $p<0.05$

Table 3: Comparison of simulation outcome

	2D Simulation		3D simulation		No difference		*p*-value
	frequency	%	frequency	%	frequency	%	
Result	4	20	15	75	1	5	<0.001*
Recommendation	7	35	12	60	1	5	0.011*

The data was analyzed using the one-sample chi-square test.
*Statistically significant at $p<0.05$

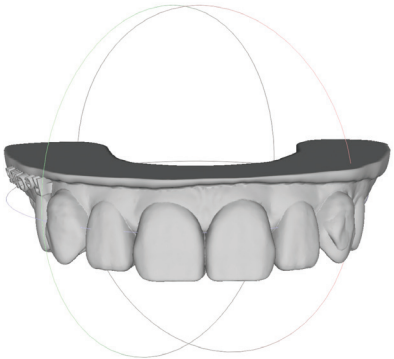
Table 4: Comparison of overall simulation system satisfaction

	2D Simulation		3D simulation		No difference		*p*-value
	frequency	%	frequency	%	frequency	%	
Overall	8	40	10	50	2	10	0.74

The data was analyzed using the one-sample chi-square test.

simulation process, the software developers created the artificial intelligence (AI) to analyze the vertical axis of the midface on videography based on the subject's facial anatomy (Figure 2B). After the vertical axis of the midface was adjusted, another component of artificial intelligence integrated the designed 3D model into the intraoral scanner's 3D model of the patient's tooth (Figure 3).

(A) Intraoral scanned model



(B) Designed 3D model

Figure 3: 3D model. (A) Intraoral scanned model, (B) Designed 3D model.

Nowadays, the digital transformation of healthcare is becoming increasingly important for both academics and clinicians.[21] Patients are also becoming active decision-makers in their medical care process as a result of the rise of digital technologies.[22] Many technologies emerge in every generation. Generation Z, or Zoomer, which was born in 2000 and refers to the young generation, becomes the main target group in this study. Regarding Ripton's article[23], it stated that generation Z and millennials are easily penetrating digital healthcare. For instance, more than 40% of that group tends to use online reservations for making a doctor's appointment. Likewise, approximately 25 million Americans use digital devices for healthcare lifestyle detection and status. Thus, this study encourages the development of dental digitalization for advanced benefits in the future.

In clinical settings, the utilization of a wide variety of digital tools to support treatment planning and rehabilitation has become increasingly common. The simulation of the smile design is possible with some of the software applications used in the esthetic planning process.[19] This helps to improve communication between patients, dental technicians, and clinicians. Utilization of digital technologies in the 3-dimensional design creates truly natural, individualized, and aesthetically attractive smiles. Digital smile simulation has become the standard for esthetic treatment plans.[24] Regardless of prosthodontic design, digital smile simulation has recently been reported to be beneficial to periodontal plastic treatment[25], orthodontic and interdisciplinary treatment plans.[26] However, there are still significant improvements to be made to this approach, primarily due to hardware and software limitations. It is a huge investment for contemporary dentistry practices, and there is a learning curve required to achieve ideal results.[27] Lastly, compared to conventional methods of smile design and wax-up, this digital system is still time-consuming and relies on clinician's experience.[28]

This is a study conducted in a single location. Some of the findings are in accordance with the existing literature, but more research is required prior to making definitive conclusions. Future studies should investigate into patients' satisfaction with alternative simulation software as well as other factors example comparing the outcomes of 2D and 3D smile simulation and the outcome of postoperative treatment. Furthermore, patient satisfaction studies with different generations of volunteers could be conducted.

Conclusions

Within the limitations of this study, patient preferences were not different between 2D and 3D digital smile simulation results, even though participant satisfaction in the 2D simulation was higher than in the 3D simulation during data collection.

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Conflicts of Interest

The authors declare no conflicts of interest.

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Oral Health Literacy and Health Seeking Behavior of Older Adults in Rural Community

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Abstract

Objectives: This community-based cross-sectional study aimed to examine health information seeking behavior regarding oral health and oral health literacy and their relationship in older adults.

Methods: The research was conducted with 432 participants from the rural area of, Noen Maprang District, Phitsanulok province, Northern Thailand. To measure oral health literacy, modified Short Test of Functional Health Literacy in Dentistry for Older Adults was used. The adapted questionnaire was used to collect health information seeking behavior in the past 3 months.

Results: Only 12.3% demonstrated adequate oral health literacy. Some 27.1% presented active health information seeking behavior, 57.3% presented passive health information seeking behavior and 15.6% had never obtained or sought any oral health information. The association between health information seeking behavior and oral health literacy could not be observed. Television, health personnel, family members/relatives and village health volunteers were the most popular information sources.

Conclusions: By adding oral health information and improving skills of oral health information for village health volunteers, it is possible to develop oral health literacy in older adults in rural areas.

Keywords: health information seeking behavior, older adults, oral health literacy

Introduction

Health literacy (HL) relates to health outcomes and self-care behaviors. Persons of all ages who presented low HL were more likely to hospitalize, to use emergency care and have less access to screening and vaccination. [1] However, in older adults, inadequate HL negatively correlated to hospitalization and emergency room visits[2] and more likely reported health-related limitations including physical function and activity and demonstrable lower scores of subjective general health.[3] HL has been related to cognitive and social skills and ability of individuals to gain access to health information, and their understanding and capacity to use information effectively for promoting and maintaining health.[4] Thus, HL could direct individuals to achieve knowledge and personal skills and take actions to change their lifestyles and living conditions to achieve good health. As HL has been concerned with the knowledge and ability of people to meet complex health needs, Sørensen and colleagues[5] reviewed the definitions and the conceptual models of HL and proposed an integrated model of HL. The ability, in the integrated model, was defined as the process of accessing, understanding, appraising, and applying health related information and those abilities have been proposed as the core competencies of HL. To achieve HL, the process starts with access to health information that refers to the ability to seek, to find and to obtain health information.

Health information-seeking was defined as the process of an individual using different methods to seek information based on different motivations, stimuli and situations to improve health.[6] The correlation between HL and health information seeking behaviors (HISB) had been reported in previous studies. The study of HL in low-income populations found that the low HL pregnant women were less likely to use the internet and had more personal barriers to seek information than those who had high HL. However, significant differences in obtaining information from interpersonal sources, health fairs, or health organizations were not observed.[7] The study in older Korean adults also reported a positive correlation between HL and information-seeking preferences after adjustment for demographic and illness variables.[8] Lee and colleagues also found Minnesotan adults who presented high level of HISB on the internet had greater access to mobile phones, computers or tablets.[9] The HISB had not been determined only to actively seek information but also passively to obtain health information.

Various wordings have been used to describe the actions of accessing health information[5] such as to gain access, to seek out, to find, to obtain. Lalazaryan and Zare-Farashbandi categorized the information seekers into three categories as active, passive information seekers, and information "blunters". Active seekers actively search when they are in stressful or health threatening situations, while information blunters actively seek and keep awareness of new information.[6] Drummond *et al*., defined methods of obtaining health information as active HISB that referred to the process of looking for and seeking for information, and passive HISB that referred to the process in which a person encounters information and decides on the attention given to it.[10]

Active HISB may be associated with higher HL, health behaviors and consequently health outcomes. The evidence from previous studies in older adults reported the higher HL was negatively related to risk behaviors but showed positive relations to health behaviors such as having regular health examination, self-reporting good health and more likely to sufficiently access multiple health information sources.[11]

Oral health literacy (OHL) has become a major concern to promote oral health and achieve quality of life. Several tools were developed to measure OHL in older adults. Rapid Estimate of Adults Literacy in Dentistry (REALD-30) has been used to assess word recognition efficiency[12], but the word comprehension could not be tested. Test of Functional Health Literacy in Dentistry (TOFHLiD) aimed to test functional dental health literacy by measuring reading comprehension and numerical ability.[13] With concern for the cultural diversity, the Test of Functional Health Literacy in Dentistry for Older Adults (OA-TOFHLiD) had been developed from Thai Older adults and reported with acceptable validity and reliability.[14] However, the OA-TOFHLiD was required much time for assessment and the older adults could not answer independently, the Short OA-TOFHLiD that excluded the session about reading and answering; modified toothpaste and mouthwash labels[15], were used in this study.

In Thai older adults, the prevalence of low and inadequate OHL were reported as 49.3%[16] and 45.2%.[17] This evidence also reported negative associations between low OHL and < 20 remaining teeth,[16] less number of natural

functional teeth to occlude and less number of posterior occluding pairs.[17] The 8th Thai National Oral Health survey reported that 54.7% and 36.2% of older adults aged 60-74 years obtained oral health information from health personnel and television. Only 2.4% of them looked for the information from the internet (Website, Facebook, or LINE).[18] However, the evidence of HISB and OHL and their association has been limited. This study aimed to examine HISB regarding oral health and OHL and to investigate the relationship between the HISB and OHL in older adults.

Materials and Methods

Study design

The community-based cross-sectional study was conducted in Noen Maprang District, Phitsanulok province, Northern Thailand. The district is rural, consisting of 7 subdistricts with 6,120 older adults aged 60-79 years old.[19] Dental personnel and dental care accessibility can reflect the availability of oral health information. The 4 subdistricts were selected as a study area according to the following criteria: 1) whether there were dental personnel in the Tambon Health Promotion Hospital (primary care unit), and 2) low or high percentage of dental care accessibility. From the Thai health data center[19], the two areas presented with the highest and the lowest percentage of access to dental service were included.

Older adults who presented mental health problems, were illiterate, or were unable to communicate were excluded. The 432 participants were included in this study by using proportion sampling according to the number of older adults in subdistricts and systematic random sampling methods. Data collection was administered during November 2019 to February 2020. Ethical approval was received from the Ethics Committees of the Faculty of Dentistry, Chiang Mai University (63/2562).

Oral health literacy (OHL)

Modified form of the Short Test of Functional Health Literacy in Dentistry for Older Adults (The Short OA-TOFHLiD) was used to measure OHL. The test consists of 39 questions with 4 alternatives. The total score ranged from 0 to 39. The inadequate OHL was score 0-34 and adequate OHL was score 35-39, with 60% sensitivity and 60.7% specificity.[15]

Health information seeking behaviors (HISB)

The questionnaire was constructed by researchers to collect HISB for dental health in the past 3 months. The questionnaire consisted of 4 parts: 1) the frequency of information seeking and information sources, 2) content and information sources 3) satisfaction with the information (rated 3 to 1 from high to low level of satisfaction) and 4) barriers to information seeking (yes/no). The content validity of the questionnaire was evaluated by using the Index of Item-Objective Congruence from 3 experts with experience of surveys. To achieve reliability, the researcher did a pilot study in 30 older adults in the district, which was not included in this study, with kappa value >0.70. For data collection, 8 research assistants were trained until they felt confident to collect demographic data and to interview the HISB. Active HISB was determined as seeking at least one issue of oral health information in the past 3 months. Passive HISB was defined as to never seek, but only obtain oral health information. No active and no passive HISB was determined to have never sought or obtained any oral health information.

Sociodemographic variables including gender, age, educational level, occupation and monthly income, and oral health satisfaction were collected by questionnaire.

The sample size was determined according to previous studies, the expected percentage of adequate OHL in older adults was 54%,[14] considering a confidence level of 95% and precision of 5%. To compensate for 20% attrition, the sample size was 432.

Data analysis

Percentage, mean standard deviation (sd) was used in descriptive statistics. Chi-square or Fisher's exact test were used to examine the differences in demographic and HISB between adequate and inadequate OHL. Odds ratios which were modeled by logistic regression were calculated to describe the association between HISB, barrier to information seeking and OHL. In this study, SPSS (Ver.24) was used with a significance level of 0.05.

Results

A total of 431 older adults (99.7%) participated in this study with a mean age of 65.58 years old (sd 4.1). The majority graduated primary school, were growers, and had low income (<3000 baht/month). 55.7% had dental treatment in the previous whole year, and 76.8%

reported satisfaction in their oral health status. 12.3% of older adults demonstrated adequate OHL and different percentages of adequate OHL were observed according to educational level, occupation, and income, with statistical significance (Table 1). The majority (84.4%) had accessed oral health information and the 57.3% and 27.1% of them reported passive HISB and active HISB. Only 15.6% of participants had never obtained or sought any oral health information. The statistically significant difference between HISB and adequate OHL was observed (Table 1).

Factors related to OHL were presented in Table 1. In crude analysis, higher income positively associated with adequate OHL. Older adults who graduated primary school were more likely to have adequate OHL than those who uneducated. In occupation variable, pensioners were positively association with adequate OHL, but the finding was conclusive as the statistically significant was reported with a wide range of 95% confidence interval. In multivariable analysis, the reverse association was observed in primary school when compared to uneducated.

The distribution of passive and active HISB by information sources was described in Table 2. Most participants access oral health information from television, doctors/nurses/public health officials. While television, radio/community radio and public address vehicles/village public address tower were passively accessed by older adults, a higher proportion of active HISB older adults seeking oral health information from village health volunteers (VHVs), internet, doctors/nurses/public health officials, parents/relatives/offspring and books/magazines/newspapers were observed.

Oral care products and teeth brushing were among the most common oral health information accessed by the elderly. Among active HISB, causes of tooth loss, periodontal disease, toothache, dental prostheses, and oral cancer were the top five content items actively sought, while xerostomia was not sought (Table 2). Barriers to health information-seeking associated with inadequate OHL were shown in Table 3. Not knowing how to get information and no transportation were significant barriers to adequate OHL.

Discussion

This study reported the active HISB older adults were more likely to demonstrate adequate OHL than those who were passive or without HISB. However, the association between HISB and OHL could not be observed. Only12.3% of participants demonstrated adequate OHL. The 27.1% presented active HISB, 57.3% presented passive HISB and 15.6% had never obtained or sought any oral health information.

The percentage of adequate OHL, in this study, is lower than previous studies that reported 50.7%[16] of high OHL and 54.5%[17] in older adults in Southern and Northern Thailand. High and moderate OHL were reported as 38.3% and 30.1% of non-institutionalized Brazilian older adults,[20] while the 19.3% and 29.6% of high and moderate OHL of the institutionalized Indian elderly were reported.[12] The percentage of OHL level varied among studies, which might be due to differences in socio-demographic characteristics. In our study, 91.4% of elderly had graduated primary school or lower, while a previous study of the Thai elderly reported 77.6%[16] graduated primary education or lower, and 53% graduated high school or lower.[17] Previous evidence, including this study, have observed the inverse association between lower educational level, income, and higher level of OHL.[12,16,17]

In addition, the percentage of older adults with adequate OHL, among studies, could not be compared because different tools had been used for OHL assessment. Rapid Estimate of Adult Literacy in Dentistry (READ-30)[12] aimed to test word recognition and reading comprehension. The Health Literacy in Dentistry scale (HeLD-Th),[20] and that validated in Thai[16] aimed to assess comprehensive ability including understand, access, evaluate information and decision making. This study used the modified Short OA-TOFHLiD[14] adapted to the Thai context, and aimed to assess functional oral health literacy including word recognition, numeracy and reading comprehension of the older adults.

In this study, we categorized HISB into active and passive manners. Our findings were consistent with the 8th Thai National Oral Health survey that reported public health officials, VHVs and television were the most popular oral health information sources for older adults.[18] Television and radio could deliver the mass media and be easy to access, while the older adults could access the information from health personnel when they made a dental visit at hospital or at the primary care unit. According to the health information culture in Thai context, television and radio are the main sources of information for the elderly. Dharma content and herbal infor-

mation related to health had been delivered through the television or radio, while "village public address tower" has been used mainly for informing on local specific issues and a few items of content related to health.[21] VHVs, who were the respected members of their villages where they lived and work, were briefly trained in health promotion and disease prevention.[22] The elderly felt free to ask or to consult VHVs for oral health information. The positive association between adequate social support and better literacy OHL, and less hospital admissions had been reported in older Chinese adults.[23] The higher proportion of the elderly who actively accessed oral health information, more often accessed oral health information from VHVs, health personnel, books/magazines/newspapers, and internet, compared to other information sources demonstrated in this study.

Table 1: Demographic data and association between factors and adequate oral health literacy

Characteristics	N (%)	Adequate OHL N (%)	Inadequate OHL N (%)	*p*-value[1]	Crude OR[2] (95%CI)	Adjusted OR[3] (95%CI)
Number of older adults	431	53 (12.3)	378 (87.7)			
Gender				0.143		
Male	202 (46.9)	30 (14.9)	172 (85.1)		Reference	
Female	229 (53.1)	23 (10.0)	206 (90.0)		0.64 (0.36, 1.14)	0.89 (0.47,1.71)
Age (years)				0.074		
60-69	337 (78.2)	36 (10.7)	301 (89.3)		Reference	
≥ 70 (70-74)	94 (21.8)	17 (18.1)	77 (81.9)		0.52 (0.29, 1,02)	
(Mean=65.58 ; sd= 4.1)						
Education				<0.001*		
Uneducated	8 (1.8)	3 (37.5)	5 (62.5)		Reference	Reference
Primary School	386 (89.5)	37 (9.6)	349 (90.4)		0.18 (0.04, 0.77)*	0.14 (0.03, 0.66)*
Secondary School	31 (7.2)	10 (32.3)	21 (67.7)		0.79 (0.16, 4.00)	0.51 (0.09, 2.99)
Bachelor's degree	6 (1.4)	3 (50.0)	3 (50.0)		1.67 (0.19, 14.27)	0.50 (0.04, 6.05)
Occupation				0.016*		
Unemployed	64 (14.8)	6 (9.4)	58 (90.6)		Reference	
Agriculturist	203 (47.1)	25 (12.3)	178 (87.7)		1.36 (0.53, 3.47)	
Pensioner	6 (1.4)	3 (50.0)	3 (50.0)		9.67 (1.58, 58.93)*	
Housewife	61 (14.2)	5 (8.2)	56 (91.8)		0.86 (0.25, 2.99)	
Employee	57 (13.2)	5 (8.8)	52 (91.2)		0.93 (0.27, 3.23)	
Trader/Self-employed	40 (9.3)	9 (22.5)	31 (77.5)		2.81 (0.92, 8.61)	
Monthly income (Baht)				0.001*		
1 - 3,000	322 (74.7)	29 (9.0)	293 (91.0)		Reference	Reference
3,001 - 10,000	86 (20.0)	16 (18.6)	70 (81.4)		2.31 (1.19, 4.48)*	1.82 (0.88, 3.79)
10,001 - 15,000	12 (2.8)	4 (33.3)	8 (66.7)		5.05 (1.43, 17.80)*	3.25 (0.84, 12.56)
≥15,000	11 (2.5)	4 (36.4)	7 (63.6)		5.77 (1.60, 20.90)*	2.69 (0.53, 13.66)
Past dental experiences in the last 1 year				0.107		
No	191 (44.3)	29 (15.2)	162 (84.8)		Reference	Reference
Yes	240 (55.7)	24 (10.0)	216 (90.0)		0.62 (0.35, 1.11)	0.62 (0.32, 1.18)
Oral health satisfaction				0.862		
No	100 (23.2)	13 (13.0)	87 (87.0)		Reference	Reference
Yes	331 76.8)	40 (12.1)	291 (87.9)		0.92 (0.47, 1.79)	1.12 (0.58, 2.55)
Health information-seeking behavior				0.017*		
None	67 (15.6)	7 (10.4)	60 (89.6)		Reference	Reference
Passive	247 (57.3)	23 (9.3)	224 (90.7)		0.88 (0.36, 2.15)	0.84 (0.32, 2.15)
Active	117 (27.1)	23 (19.7)	94 (80.3)		2.10 (0.85, 5.19)	1.58 (0.58, 4.27)

*Statistical significance : *P*-value <0.05, OHL: oral health literacy, OR: Odds ratio

[1]Chi-square test, [2]Simple logistic regression, [3]Multiple logistic regression: adjusted for gender, education, monthly income, past dental experiences in the last 1 year and satisfaction with oral health condition

Table 2: Information sources and oral health information that had been accessed in the last 3 months among older adults with passive and active health information seeking behaviors

	Number (%)	Passive HISB N (%)	Active HISB N (%)
Information sources			
1. Television	385 (89.3)	358 (100)	-
2. Doctors/Nurses/Public health officials	307 (71.2)	112 (36.5)	195 (63.5)
3. Parents/Relatives/Offspring	262 (60.8)	112 (42.7)	150 (57.3)
4. Village Health Volunteers	214 (49.6)	58 (23.5)	156 (76.5)
5. Friends	181 (42.0)	84 (46.4)	97 (53.6)
6. Radios/Community radio	154 (35.7)	154 (100)	-
7. Poster/Brochure	120 (27.8)	77 (64.2)	43 (35.8)
8. Book/Magazine/newspaper	98 (22.7)	35 (35.7)	63 (64.3)
9. Public Address/Audio tower village	85 (19.7)	85 (100)	-
10. Internet	42 (9.7)	12 (28.7)	30 (71.3)
Oral health information			
1. Oral care products (e.g. toothbrush, toothpaste, mouthwash)	269 (62.4)	254 (94.4)	15 (5.6)
2. Teeth brushing	223 (51.7)	182 (81.6)	41 (18.4)
3. Toothache	185 (42.9)	136 (73.5)	49 (26.5)
4. Dental caries	172 (39.9)	146 (84.9)	26 (15.1)
5. Dental prostheses	165 (38.2)	126 (76.4)	39 (23.6)
6. Prevention of tooth loss	112 (26.0)	95 (84.8)	17 (15.2)
7. Causes of tooth loss	85 (19.7)	52 (61.2)	33 (38.8)
8. Gingivitis/ periodontitis	84 (19.4)	58 (69.1)	26 (30.9)
9. Oral cancer	53 (12.3)	43 (81.1)	10 (18.9)
10. Tooth fracture	37 (8.6)	31 (83.8)	6 (16.2)
11. Xerostomia	6 (1.4)	6 (100)	-

Table 3: Bivariable analysis of barriers to health information seeking regarding oral health and inadequate oral health literacy

Barriers to health information seeking	Number (N)	Adequate OHL N (%)	Inadequate OHL N (%)	Odds ratios (95%CI)	*p*-value[(1)]
1. Don't know how to get info	265	22 (8.3)	243 (91.7)	2.54 (1.41, 4.55)	0.002*
2. Time consuming to get info	220	29 (13.2)	191 (86.8)	0.85 (0.47, 1.51)	0.57
3. Don't know how to use the Internet	345	40 (11.6)	305 (88.4)	1.36 (0.69, 2.67)	0.38
4. No family/friends for questions	66	9 (13.6)	57 (86.4)	0.87 (0.40, 1.88)	0.72
5. No transportation	262	22 (8.4)	240 (91.6)	2.45 (1.37, 4.40)	0.003*
6. No oral health fairs/activities near home	306	37 (12.1)	269 (87.9)	1.07 (0.57, 2.00)	0.84
7. Books/magazines are expensive	244	31 (12.7)	213 (87.3)	0.92 (0.51, 1.64)	0.77
8. Books/magazines are difficult to buy	249	36 (14.5)	213 (85.5)	0.61 (0.33, 1.12)	0.11
9. Oral health care providers are not helpful	70	6 (8.6)	64 (91.4)	1.60 (0.65, 3.89)	0.30
10. Lack information from mass media	138	15 (10.9)	123 (89.1)	1.22 (0.65, 2.31)	0.54

*Statistical significance : *p*-value <0.05, [(1)]Simple logistic regression

The study of Kim and Utz in older Korean adults reported health literacy showed positive correlation with information-seeking preferences after adjustment for demographic and illness variables.[8] In this study, the association between HISB and OHL could not be observed because the sample size was inadequate to detect the association. Only 12.3% of older adults had adequate OHL found in this study, that was lower than the percentage used for sample size estimation. Trainattawan, Wirojratana, and Watanakukrilert also found that HISB through online media/social media is positively associated with HL among older Thai older adults.[24] The number of internet users in Thailand has increased across all generations.[24] The study of Kheokao J *et al.,*[25] reported that among the Thai elderly who used the internet, 75.3% went online via personal smart/mobile phone. They used the internet to connect with LINE application (85.7%), Facebook (63.1%). In terms of usage, they watched media clips or listened to music (68.9%), and searched for information and downloads (63.4%).

Healthy lifestyles, treatment and medication were the popular content that the elderly searched regularly.[26] Major oral problems from national surveys among older Thai adults were tooth loss, untreated tooth decay, attrition, needs for dental prostheses, calculus and bleeding, periodontal disease, and xerostomia.[18] In this study, causes of tooth loss, gingivitis/periodontal disease, toothache, dental prostheses, and oral cancer, sorted that order, were popular content that had been sought. Xerostomia was passively accessed by only 6 older adults and none of the participants had ever searched for this information. The findings from a previous study among smartphone users for seeking health information suggested that younger age, higher educational levels, having regular exercise, higher medical expenditure, and HL correlated to HISB.[27] This study could not observe the association of HISB and OHL. This might be due to the large number of older adults who were determined as having inadequate OHL, and consequently the association could not be detected. However, the increasing trend of using the internet, particularly on personal smart/mobile phones in elderly, can increase the potential to actively access oral health information.

Not knowing how to get information and having no transportation were significant barriers to access information in our study population. Some did not know how to access the internet, and some had no idea how to search. In addition, no oral health fairs were located nearby and they could not go to the information sources such as community hospitals or primary care units. The barriers to HISB have been proposed as individual factors which were: degraded physical function, lack of HL and lack of information search skill. Lack of social support was determined as inadequate family support, limited access to professional health service, lack of health information services/sources and inadequate control of health information quality by the government.[28]

Increasing access to oral health information could be considered with various types of HISB. Television and radio are effective channels to passively deliver oral health information. However, the quantity and variety of content and essential information for the elderly will be new challenges. Improving the skills of VHVs to give consultations, and to help the elderly to prevent problems or promote oral health, could encourage older adults to actively access oral health information and further create more flexible interactions. As internet users, reliable sources of information on internet or social media, and essential content about xerostomia or dysphagia, and quality of oral health information should be adequately controlled. In further study, the availability, accessibility of oral health information and effectiveness of communication should be evaluated with both quantitative and qualitative research.

There are some limitations to this study. We assessed only access to oral health-related information that is one out of four competencies of HL. To achieve oral health by developing OHL, the ability to understand, to appraise and to apply oral health information should be further considered. The study participants were older adults in rural areas, so comparing our findings to other studies should consider different contexts and cultural diversity. Lastly, the questionnaire survey had limitations for giving explanations from some perspectives such as quality of information/sources and difficulties to access information.

Conclusions

Older adults with active HISB tended to demonstrate adequate OHL than those who were passive or without HISB. Television, health personnel, family members/relatives and VHVs were the most popular oral health information sources. Not knowing how to get information

and no transportation were significant barriers to access information. Increasing access to information by inserting oral health information in television, radio, internet, and social media, improving information search skills for the elderly, and improving oral health information skills for VHVs could be able to develop OHL in older adults.

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Conflicts of interest

The authors declare no conflict of interest.

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Statement of Ethics

The study protocol was approved by the Human Experimentation Committee of the Faculty of Dentistry, Chiang Mai University. (No. 63/2019) Study participants have given their written informed consent.

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Droplet Spread Pattern Produced by Magnetostrictive Scaling with and without a High-volume Evacuator

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Abstract

Objectives: To study the droplet spread pattern from magnetostrictive scaling and the effect of a high-volume evacuator (HVE) on spread reduction.

Methods: Magnetostrictive scaling was simulated on a dental unit using dye-stained water. Gridded filter paper was installed at five vertical heights. Each height consisted of a center point with six radial directions, each divided into four horizontal distances. Eight minutes of scaling was performed in triplicate for two groups, scaling with HVE (H) and scaling without HVE (NH). The stained paper grid cells were counted, and the number and percentage of stained cells were calculated. Statistical comparison of H and NH was performed using SPSS.

Results: The 2 and 4 o'clock directions showed the highest number of stained areas in both groups. Pieces of paper located 30 cm from center horizontally in all directions from floor level up to 30 cm above the scaler tip were completely stained in both groups. The furthest distance that droplets spread was 120 cm from center at 2 and 4 o'clock in the NH group. The highest vertical spread was 45 cm above the tip in both groups and it was significantly decreased in the H group. The total stained area was reduced by 3.15% when using HVE.

Conclusions: Droplet spread from magnetostrictive scaling can reach 120 cm from the dental unit in the 2 and 4 o'clock directions. An HVE with adequate airflow rates is necessary for reducing contamination risk.

Keywords: high-volume evacuator, scaling droplets, spread pattern, ultrasonic scaler

Introduction

The coronavirus disease (COVID-19) pandemic has affected socioeconomic and health issues worldwide. The infection of the respiratory tract caused by the SARS-CoV-2 virus generally causes a wide range of symptoms, from mild fever or coughing to life-threatening complications. As of the writing of this article, 6.5 million people worldwide and over 30,000 people in Thailand have died from COVID-19 infection since its outbreak in 2020.[1] It is well known that the transmission of COVID-19 primarily occurs between people at a conversational distance through droplet transmission, which occurs when an uninfected person inhales droplets generated by an infected person coughing, speaking, or breathing. In 2021, the World Health Organization announced that COVID-19 can additionally spread in poorly ventilated environments via airborne transmission, remaining suspended in the air for a longer period and traveling farther than conversational distances.[2] This increased the concerns of viral transmission during dental procedures.

Periodontal scaling using ultrasonic scalers is a fundamental and routine dental procedure that aims to remove bacterial plaque and calculus from the gingival sulcus. Regular professional scaling is critical for maintaining periodontal health and preventing the development of periodontal disease, the common oral disease that leads to tooth loss. Ultrasonic scaling is an aerosol-generating procedure due to its high vibrational energy combined with the necessary use of water coolant. Although there are no reports of transmission of COVID-19 to dental staff from infected patients,[3] the anxiety of both patients and dental staff has been heightened due to the unavoidable direct contact in a closed environment that occurs between dental staff and patients' oral cavities during these dental procedures.

Numerous studies have investigated the bacteria-contaminated areas generated by ultrasonic scaling and methods to reduce contamination, such as pre-procedural rinsing with disinfectant and using a high-volume evacuator (HVE).[4-8] However, the majority of studies have not extensively evaluated the spread pattern of droplets, leading to an incomplete understanding of the pattern of maximal spread.[4,5,8-10] Moreover, differences in research methodology (simulated or clinical tests)[7,10] and unclearly defined experimental setups, including incomplete information regarding the type of scalers, position of scaler tip, and environmental considerations such as the presence of an air conditioner, have caused further controversy in the results of previous studies.[5-7] Therefore, the present study aimed to evaluate the droplet spread pattern during ultrasonic scaling and the effect of using an HVE on droplet reduction.

Material and Methods

This laboratory research was conducted at the Periodontology Clinic, Faculty of Dentistry, Chiang Mai University, Thailand. The dental unit was adjusted to a fully supine position with the headrest positioned 75 cm from the ground. The tip of the magnetostrictive scaler (Scalex 800 Ultrasonic Scaler, Dentamerica Inc., San Jose, CA, USA), which is routinely used in the undergraduate clinic of the faculty, was fixed in a position perpendicular to the floor. To simulate the portion of the scaling produces the highest droplet volume and prevent factors affecting the droplet spread pattern, scaling was performed in one fixed position that mimicked the scaling of the palatal surface of the upper incisors. The HVE was installed on the left side of the unit, 2 cm from the scaler tip. Pieces of paper measuring 9x9 cm with 324-cell grids were used to trap the colored droplets during scaling. The water coolant was mixed with carmoisine dye at a ratio of 1 g of dye to 3 L of water.

Droplet spread was assessed at five vertical heights: the level of the floor, the level of the scaler tip, 30 cm above the tip, 45 cm above the tip and 60 cm above the tip. At each vertical height, the direction of spread was examined in the 12, 2, 4, 6, 8 and 10 o'clock directions, excepted for 6 o'clock at the level of the floor which was the area under the dental unit, and horizontal distance in each direction was assessed at 0, 30, 60, 90 and 120 cm from the center point. The experimental setup is shown in Figure 1.

The experiment, which was repeated three times of each height level, consisted of 8 min of scaling with HVE and 8 min of scaling without HVE. The air conditioner vents were closed to prevent interference with droplet spread. The grid cells with colored stains were then counted, and the sums and percentages of stained cells were calculated as shown in Figure 2.

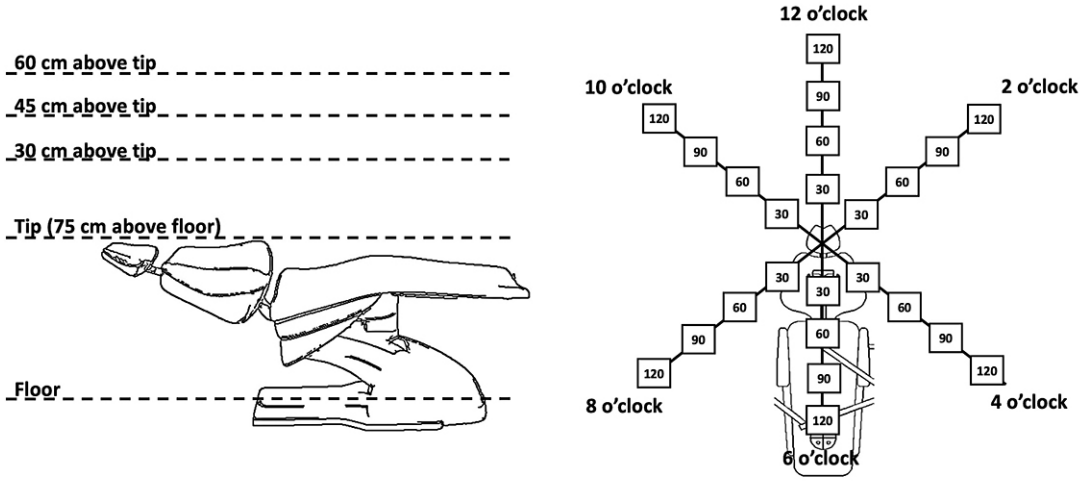

Figure 1: Position of installed grid paper at different vertical levels (left) and horizontal distances. The unit of horizontal distance was centimeters.

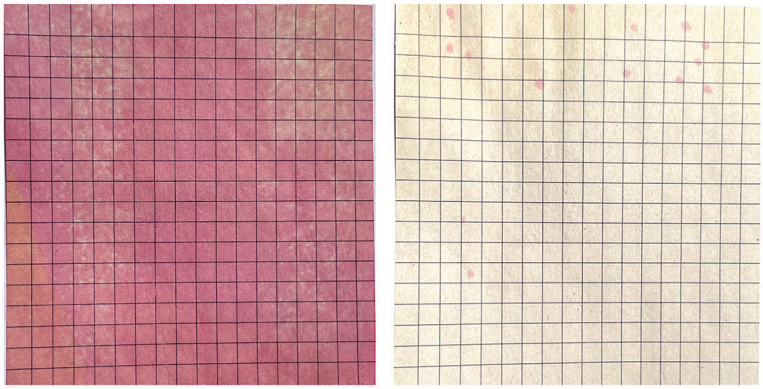

Figure 2: The examples of gridded filter paper after scaling. The number of stained cells was counted as 324 (100%) and 18 (5.56%) for the left and right, respectively.

Statistical analysis

Data were analyzed using SPSS (Windows version; SPSS, Chicago, IL, USA). The Shapiro–Wilk test was used to demonstrate the non-normal distribution of the data. The number of stained grid cells obtained from triplicate scaling was calculated into the mean. The total number of stained grid cells that occurred during scaling with and without HVE at each vertical height, direction, and horizontal distance was compared via the Mann–Whitney U test. A p-value of < 0.05 was considered statistically significant.

Results

In the direction of droplet spread, the most stained area during scaling without HVE was in the 2 o'clock direction, followed by the 4 o'clock direction. With the addition of the HVE, the stained areas decreased at 2 and 4 o'clock but slightly increased at 8 and 10 o'clock. The farthest distance of droplet spread was 120 cm from center, which occurred in the 2 and 4 o'clock directions at floor level only when scaling without the HVE. However, the difference of number of stained grid cells from scaling with and without HVE was not significant (Table 1).

Considering the vertical level, the pattern of droplet distribution was relatively similar with and without the HVE. All pieces of paper located at a horizontal distance of 30 cm from center in all directions from the floor level up to 30 cm above the tip were fully covered in droplet stains, while staining was substantially decreased and absent on paper located 45 and 60 cm above the tip,

Table 1: Mean number of stained grid cells from scaling alone and with HVE in each direction and horizontal distance

		Direction (o'clock)											
		12		2		4		6		8		10	
		NH	H	NH	H	NH	H	NH	H	NH	H	NH	H
Horizontal distance (cm)	30	965.8	973.3	1055.7	971.7	766.7	663.0	654.0	648.7	972.3	943.7	827.0	985.8
	60	342.3	324.3	686.0	608.4	539.0	321.6	0	6.3	18.0	303.7	18.3	55.7
	90	5.7	5.8	227.7	21.7	15.3	28.7	0	0	1.0	25.3	6.7	6.0
	120	0	0	2.0	0	2.0	0	0	0	0	0	0	0
	Sum	1313.8	1303.4	1971.3	1601.8	1323.0	1013.3	654.0	655.0	991.3	1272.7	852.0	1047.6
p-value*		> 0.05		> 0.05		> 0.05		> 0.05		> 0.05		> 0.05	

H = scaling with HVE; NH = scaling without HVE; *Number of stained grid cells from H and NH at each direction was compared via the Mann–Whitney U test.

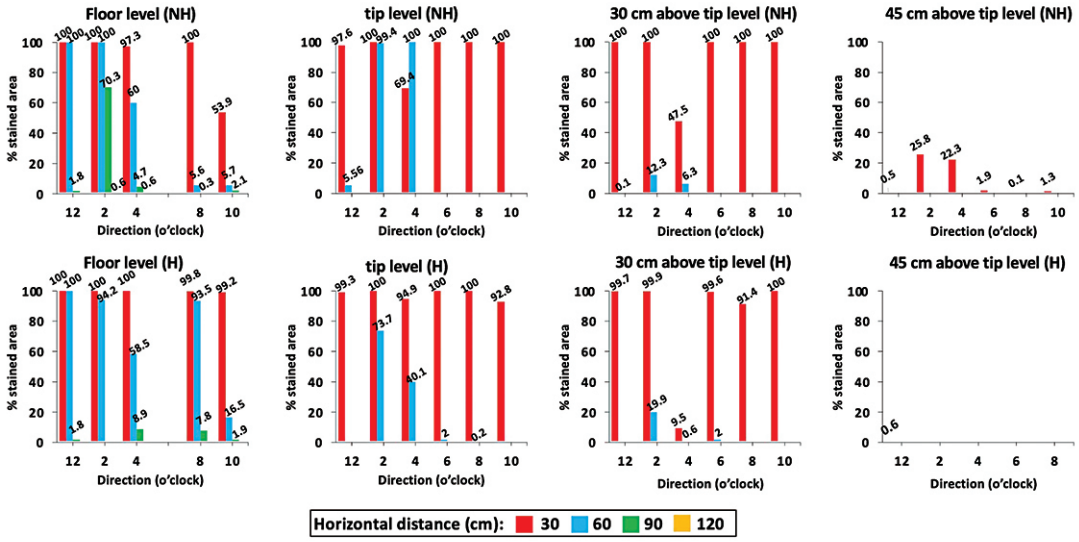

Figure 3: Percentage of stained area from scaling alone and with HVE at four vertical levels. H = scaling with HVE; NH = scaling without HVE.

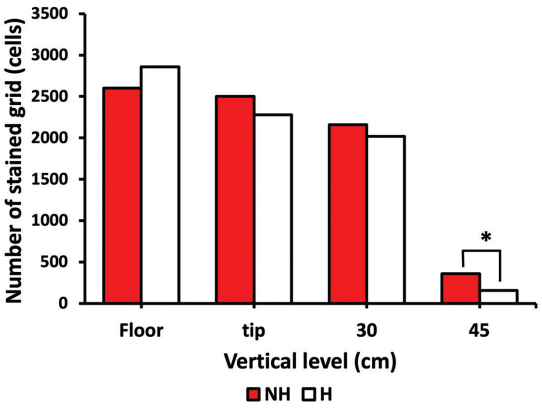

Figure 4: Number of stained grid cells from scaling alone and with HVE in each vertical level. * = comparison between NH and H tested via the Mann–Whitney U test. H = scaling with HVE; NH = scaling without HVE.

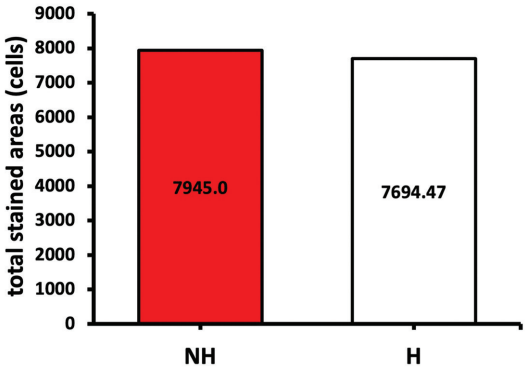

Figure 5: Comparison of total stained area between scaling alone and with HVE. H = scaling with HVE; NH = scaling without HVE.

respectively (Figure 2). At 45 cm above the tip, stained regions were significantly decreased when the HVE was used, while the significant difference at the other vertical level was not observed (Figure 3). The total stained surface during scaling with the HVE was 3.15% insignificantly less than the total stained surface during scaling without the HVE (7105.4 cells vs 6893.8 cells, respectively) (Figure 4).

Discussion

The present study showed that the droplet spread direction with the most color staining occurred at 2 and 4 o'clock, both with and without using an HVE, which corresponds to the working position of the dental assistant. This is in agreement with a previous study that found that the 4 o'clock direction was the most contaminated area immediately and up to 30 min after 15 min of ultrasonic scaling.[6] Moreover, previous studies have demonstrated that the areas corresponding to the nose and chest of the dental assistant had a high risk of contamination, comparable to the areas of the dentist's and patient's chest.[11] This is in line with our results showing complete staining of all paper located 30 cm horizontally from center in every direction from the floor level up to 30 cm above the tip. These findings highlight the importance of maintaining strict contamination prevention measures for all staff positioned around the dental unit, not only the operator and patients. However, one previous study presented a controversial result in its finding that the assistant was in the position with the lowest contamination compared to the dentist and patient.[5] This might be due to the study's experimental methodology, as the study was performed in a real clinical environment in which the position of the scaler tip moved during scaling, while our study was a simulation test in which the scaler tip was fixed throughout the experiment. Our attempt to reduce confounding factors affecting droplet spread by fixing the scaler tip might lead us to understand more clearly in possible spread pattern generated by magnetostrictive scaling.

In addition, we found that the farthest distance of droplet staining was 120 cm from center horizontally and 45 cm above the tip vertically, which is consistent with the findings of several previous experiments.[6,10] However, other studies demonstrated that bacterial contamination could be found up to 300 cm from the oral cavity on the floor or even on the ceiling.[12,13] These conflicting reports might be a result of differences in study designs, particularly in the method employed to detect droplets. In the present study, we used grid paper to absorb colored water, while the counting of bacteria-forming units on agar plates was performed in previous studies. Although their technique might elicit a higher sensitivity for aerosol detection, the challenge of controlling contamination from other sources could lead to false-positive outcomes. Therefore, it is impossible to conclude the actual distance of viral contamination from the current evidence, but overestimating viral spread might be considered for the purpose of prevention. Regardless, no contamination occurred at 120 cm from center in the 2 and 4 o'clock directions when scaling was combined with HVE in this study, which indicates that HVE might limit the radius of droplet spread during scaling.

The present study further demonstrated that the application of an HVE during scaling reduced the stained area by merely 7.2% compared to scaling alone. This is consistent with one study that found no significant difference

in colony-forming units between scaling with and without an HVE.[14] However, a group of earlier studies suggested that placing a large-bore HVE within 2 cm of the scaler tip reduced splatter by more than 93%,[15-17] which was in agreement with additional studies that showed contamination reduction rates of 83% to 94% when using an HVE, evaluated by the staining of filter paper strips, the number of colony-forming units, and the area of image subtraction.[8,11,18] Desarda and colleagues speculated that high efficacy when using an HVE might be achieved by modifying the device, such as by attaching the HVE tip to the scaler handle so that they act as a single unit.[14] The low efficacy of the HVE in our study was likely contributed to by an inadequate suction flow rate (120 L/min) of the dental unit, as one study illustrated that 160 L/min was the minimum flow rate required for the prevention of particle emission.[19] Moreover, a recent study conducted by Li and colleagues demonstrated that a flow rate of 300 L/min induced significantly more effective particle removal than flow rates of 150 L/min or lower, as assessed by a laser light-scattering technique.[20] This was in line with the findings of Puljich's study, in which a flow rate of 325 L/min obtained a reduction rate of over 80%.[8] It was suggested that regular maintenance and evaluation of suction flow rate are crucial. Nevertheless, our findings showed that despite a potentially inadequate flow rate, using an HVE could limit the radius of droplet spread at a vertical level of 45 cm above the scaler tip and a horizontal distance of 120 cm from center in the 2 and 4 o'clock directions. No previous studies have shown complete prevention of contamination from using an HVE alone. Recently, several studies demonstrated a significantly higher efficacy in reducing aerosols when using HVE combined with extraoral suction devices.[21-23] These studies employed combination protocols to optimize the prevention of COVID-19 and other airborne disease transmission. Further studies in confined settings and with consistent methodology are still needed to clarify the pattern of droplet spread.

The present study had some limitations. First, it was a simulation study, which was free of the confounding impact of an air conditioner and used a fixed-position scaler tip; the observed spread pattern thus might not be applicable to clinical scenarios. However, the outcome obtained with the scaling in the position that produces the most droplet spread should be a reminder of the possibility of viral transmission even in low-risk situations. Second, the result obtained using a magnetostrictive scaler may not be transferable to other types of scalers, such as piezoelectric scalers, due to their different mechanisms. Finally, droplet detection via filter paper may only detect large molecules, such as splatter or droplets, but not aerosols, which might have led to underestimated results. Further investigation using bacterial culture plates as the detection method may be required.

Conclusions

The droplets generated from magnetostrictive scalers had a maximal spread at the left side of the operator, with maximum distances of 120 cm horizontally and 45 cm vertically from the scaler tip. Although using an HVE might limit droplet spread in both dimensions, an inadequate airflow rate led to lower efficacy in spread reduction.

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Conflicts of interest

The authors declare no conflicts of interest.

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Validity of a Simple Periodontal Disease Screening Tool in Thai Patients

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Abstract

Objectives: To develop and evaluate the validity of a self-reporting questionnaire for periodontitis in the Thai population.

Methods: A cross-sectional analytical study was performed in a group of 300 Thais aged 19-85 years old at the Faculty of Dentistry, Chiang Mai University. Each participant took a questionnaire and received a periodontal status evaluation. Participants were classified into three severity groups using the Centers for Disease Control and Prevention, in partnership with the American Academy of Periodontology (CDC-AAP) criteria. Multivariable ordinal logistic regression analysis was used to achieve the final model. The scoring system was also developed.

Results: One hundred patients of each severity group were recruited. Significant predictors in the final model included age, gender, bleeding gums, tooth mobility, dental flossing, dental check-up frequency, diagnosis by a dentist, and individual assessment of periodontitis. The total derived scores identified the severity group of patients into no/mild, moderate, and severe periodontitis. Our model predicted severity groups correctly in 65.7% of patients, while giving an underestimation of 19.3% and an overestimation of 15%. The area under the receiver operating characteristic curves (AuROCs) equal to 0.92 and 0.80 discriminated moderate and severe from no/mild periodontitis, and severe from no/mild and moderate periodontitis, respectively.

Conclusions: Our periodontal disease screening tool demonstrates adequate accuracy. Its validity should be evaluated in other populations.

Keywords: periodontitis, questionnaire, sensitivity and specificity, Thai

Introduction

Periodontal disease is an infection and inflammatory condition that affects periodontal tissues. The most common forms of periodontal diseases are gingivitis and periodontitis. Gingivitis is a common or mild form of periodontal disease manifested by inflammation only at the gingiva. Periodontitis, a more severe, irreversible form of periodontal disease, results in the loss of tissues and bones surrounding and supporting the teeth.[1] Periodontitis is considered an important cause of tooth loss in adults. Such people are at risk of edentulism, which leads to functional and esthetic impairment that can affect individual physical health and lead to self-esteem problems.[2] Since an early stage of periodontitis usually does not present with noticeable symptoms, patients may not realize that they have a problem until they are suffering from an advanced stage of the disease. From 1990 to 2010, approximately 11.2% of the world population suffered from severe periodontitis, which is the sixth most prevalent disease in the world.[3] In Thailand, the 8th Thai National Oral Health Surveillance, conducted in 2017, reported that the prevalence of periodontitis in adults between 35 and 44 years old was 25.9%, and in the elderly between 60 and 74 years old was 36.3%.[4]

Periodontal disease can be prevented by effective daily oral hygiene care, avoiding the risk factors of periodontitis, and undergoing regular professional examination and plaque removal.[5] Although the clinical examination is a standard measure and is the most accurate way to detect periodontal disease, it is costly, time-consuming, and resource-demanding. Moreover, dental instruments and dental personnel are mandatory.[6,7] More than 60% of Thai adults have never had a dental check-up,[4] and thus, their periodontal diseases may be under-detected, which would lead to an increased opportunity of losing teeth from periodontitis.

A self-reported questionnaire could be an interesting alternative tool to assess periodontal disease in a population. It could permit not only painless early detection but would also be easy to use, low-cost, and low-resource.[7,8] However, studies in various countries have shown variation in the validity of self-reported periodontal measures.[7,9] The divergent validity outcomes regarding self-reporting questionnaires depend on population characteristics and periodontal case definition.[10] Nevertheless, many studies have been moderate to well valid for self-reported periodontal measurements when combined with demographic variables and risk factors.[10-15] In addition, the self-reported questions were written in different languages, such as Japanese[16], Chinese[17], German[8], Portuguese[15], Arabic[18], French[10] and Spanish.[19] Till now, self-reported measures have never been investigated or validated in Thailand. Moreover, there is no scoring system in existing questionnaires which could predict the severity of the periodontal disease.

Therefore, this study aimed to develop and evaluate the validity of a self-reported questionnaire to screen for periodontitis in a group of Thais attending the Faculty of Dentistry, Chiang Mai University.

Materials and Methods

Study design and sample recruitment

This cross-sectional analytical study used case-control analogue data collection. The study participants were recruited from general patients attending the dental clinic at the Faculty of Dentistry, Chiang Mai University, Chiang Mai, Thailand, between May and December 2019. The inclusion criteria were: Thais aged > 18 years old able to read and respond to a Thai self-reported questionnaire, and willing to answer the periodontal screening questionnaire. Exclusion criteria were: had fewer than 10 remaining teeth, required antibiotic prophylaxis prior to the periodontal examination, had a history of bleeding disorders, taking medications causing bleeding disorders, had drug-induced gingival overgrowth, was pregnant, and disabled or handicapped. Informed consent was obtained from each subject prior to enrolment. We considered the sample size based on a test of two independent proportions using data from previous studies[10,12,15] with a 5% significance level and 80% power. The sample size was estimated to be 100 participants in each group: no/mild, moderate, and severe periodontitis (total n=300). As the determined sample size was 100 subjects per group, every participant who met the inclusion and case definition criteria was included until each severity group reached the required sample size.

The research was approved by the Faculty of Dentistry Human Experimentation Committee, Chiang Mai University, on August 2, 2019 (No. 43/2019).

Periodontal status measurements

The periodontal status of each participant was examined using a sterile periodontal probe (PCP-UNC 15, Hu-Friedy, Chicago, IL, USA). Probing depth (PD) and clinical attachment level (CAL) were recorded. The full mouth periodontal status of each tooth, excluding third molars and retained roots, was measured in six sites (mesio-buccal, mid-buccal, disto-buccal, disto-palatal/lingual, mid-palatal/lingual, mesio-palatal/lingual), All measurements were performed by a trained resident and two periodontists, who were calibrated prior to the examination. Weighted kappa scores of inter-examiner reliability ranged from 0.87-0.98 and 0.85-0.93, for PD and CAL, respectively.

The clinical case definition of periodontitis

According to the clinical examination, participants were classified into three groups according to severity, using the definition of periodontitis proposed by the Centers for Disease Control and Prevention and the American Academy of Periodontology (CDC-AAP) Working group.[20] The criteria for classification were 1) severe periodontitis: two or more interproximal sites with CAL≥6 mm (not on the same tooth) and at least one interproximal site with PD≥5 mm; 2) moderate periodontitis: two or more interproximal sites with CAL≥4 mm (not on the same tooth) or at least two interproximal sites with PD≥5 mm (not on the same tooth); and 3) no/mild periodontitis: neither moderate nor severe periodontitis.

The self-reported questionnaire development

The self-reported questionnaire was self-administered. Each participant responded to the questionnaire on the visit after the periodontal status was determined by professionals. Due to the question of periodontal disease diagnosis, the participants were not informed about their periodontal status until the questionnaire was completed. The self-reported questions were modified from previous studies.[6,8,10,12-15,17,18,21] The questions fell into four categories:

1) Demographic features and risk factors: age, gender, education level, monthly income (<10,000 baht and > 10,000 baht/person/month according to net national income in the year 2018[22]), weight, height, alcohol consumption, smoking status and diabetes;

2) Signs and symptoms: bleeding gums, receding gums, tooth mobility, dental calculus, red and swollen gums, food impaction, tooth movement, sore gums, tooth sensitivity, malodor and individual assessment of periodontitis;

3) Oral health care: toothbrushing frequency, dental aids use and mouthwash use;

4) Dental history: dental check-up frequency, tooth loss from periodontitis, diagnosis and recommended treatment of periodontitis by a dentist, history of root planing and history of gum surgery.

Statistical analyses

All statistical analyses were conducted using STATA software version 14.0 (StataCorp LP, College Station, TX, USA). Means and standard deviations or medians and ranges were used to describe numerical variables. Frequency and percentages were used to describe categorical variables. For univariate analysis, associations between each self-reported question and the clinical definition of periodontitis were evaluated using univariable ordinal logistic regression analysis presented with crude odd ratios (crude OR), with significance set at the 0.05 level. For the final model, multivariable ordinal logistic regression analysis was defined to assess the most predictive set of variables associated with the severity of periodontitis. The predictor variables were retained if they were statistically significant (p<0.05). For the development of the scoring system and cut-off points, each significant β-coefficient was transformed by dividing using the least value of the β-coefficient of the model. Then, the transformed score of each variable was rounded up to the assigned severity score. The total scores and cut-off points were developed and tested for the discriminative capability and predictive validity which were illustrated by the accuracy percentage, the area under the receiver operating characteristic curves (AuROC), the sensitivity, and the specificity.

Results

A total of 300 participants were classified, based on the CDC-AAP criteria, into three severity groups: no/mild periodontitis (n=100), moderate periodontitis (n=100), and severe periodontitis (n=100). The periodontal parameters of each group are shown in table 1.

Table 1: Periodontal status of the study participants according to periodontal case definition

Variables	Total sample (n=300)	Periodontal case definition (CDC-AAP)			*p*-value
		Mild (n=100)	Moderate (n=100)	Severe (n=100)	
Average remaining teeth (min-max)	26.14 (11-32)	26.82 (17-32)	25.68 (11-32)	25.91 (12-32)	0.057
Average PPD (±SD)	2.59±0.58	2.31±0.40	2.48±0.39	2.99±0.68	<0.001
Percentage of sites with PPD (mean ± SD)					
≥ 3 mm	42.28±28.77	14.58±17.56	47.68±22.15	64.57±19.87	<0.001
≥ 4 mm	10.51±14.50	0.80±1.85	5.90±6.55	24.83±16.28	<0.001
≥ 5 mm	4.93±9.11	0.07±0.34	1.38±2.07	13.34±11.76	<0.001
≥ 6 mm	2.42±5.51	0.04±0.25	0.34±0.67	6.88±7.81	<0.001
Percentage of teeth with PPD (mean ± SD)					
≥ 3 mm	11.74±5.75	5.87±5.12	13.84±3.70	15.50±2.45	<0.001
≥ 4 mm	4.59±4.82	0.59±1.24	3.61±3.02	9.57±4.18	<0.001
≥ 5 mm	2.41±3.58	0.05±0.20	1.04±1.42	6.13±3.88	<0.001
≥ 6 mm	1.28±2.40	0.02±0.14	0.27±0.51	3.54±3.05	<0.001
Average CAL (±SD)	2.78±0.84	2.28±0.56	2.63±0.64	3.42±0.85	<0.001
Percentage of sites with CAL (mean ± SD)					
≥ 3 mm	47.17±31.40	12.00±15.04	56.32±20.33	73.19±17.93	<0.001
≥ 4 mm	19.43±21.08	1.20±3.11	17.13±12.98	39.95±19.94	<0.001
≥ 5 mm	9.21±13.54	0.19±0.77	5.12±6.15	22.32±15.57	<0.001
≥ 6 mm	4.58±8.53	0.03±0.18	1.49±2.46	12.22±11.13	<0.001
Percentage of teeth with CAL (mean ± SD)					
≥ 3 mm	12.10±5.55	5.56±4.27	14.80±2.69	15.94±1.49	<0.001
≥ 4 mm	6.70±5.61	0.77±1.73	7.20±3.74	12.15±3.50	<0.001
≥ 5 mm	3.75±4.29	0.14±0.52	2.78±2.43	8.32±3.76	<0.001
≥ 6 mm	2.07±3.09	0.12±0.10	0.91±1.13	5.28±3.40	<0.001

All participants responded to all of the questions. The entire sample had a mean age of 46±15 years (ranging from 19 to 85 years) with 60.67% of females. The majority of the sample had a high level of education (58.67% of bachelor's degree or more) and 68.33% had a monthly income > 10,000 baht/person/month. The average Body Mass Index (BMI) of participants was approximately 24 kg/m^2. In addition, 15.33% of patients reported alcohol consumption, 3.33% were current smokers and 9% were diabetic. (Table 2, Category I).

Table 2 shows that almost all variables were associated with the severity of periodontitis.

In Category I: Demographic features and risk factors, there were four variables, which included age, gender, smoking status, and diabetes, which were associated with the severity of periodontitis. The proportions of patients with severe periodontitis were higher in older, male, current-smoker, and diabetic patients.

In Category II: Signs and symptoms, only one variable (tooth sensitivity) was not associated with the severity of periodontitis. The proportions of participants with signs and symptoms of periodontitis were higher in the severe periodontitis group than those in the moderate and no/mild groups.

In Category III: Oral health care, two variables (toothbrushing frequency and dental flossing) were associated with the severity of periodontitis.

In Category IV: Dental history, all variables were associated with the severity of periodontitis. The proportions of participants with a history of tooth loss from periodontitis, diagnosis and recommended treatment of periodontitis by a dentist, and those receiving periodontal treatment in the past were higher in the severe periodontitis group than in other groups.

Table 2: Response to the self-reported questionnaire for the screening of periodontitis

Variable	Total sample (n=300)	Periodontal case definition (CDC-AAP)			Crude OR (95% CI)	*p* value
		No/mild (n=100)	Moderate (n=100)	Severe (n=100)		
Category I: Demographic features and risk factors						
Age (%)						
<40 years	36.67	73	20	17	1.00	
40-54 years	26.00	21	32	25	4.85 (2.70-8.72)	<0.001
>54 years	37.33	6	48	58	12.85 (7.25-22.79)	<0.001
Mean (±SD)	46±15	35±12	53±14	52±12		
Gender (%)						
Female	60.67	75	61	46	1.00	
Male	39.33	25	39	54	2.54 (1.64–3.94)	<0.001
Education level (%)						
Primary school	12.66	6	21	11	1.55 (0.84-2.85)	0.158
High school	28.67	26	25	35	1.53 (0.95-2.49)	0.082
≥Bachelor's degree	58.67	68	54	54	1.00	
Monthly income (%)						
≤10,000 baht	31.67	21	40	34	1.55 (1.00-2.41)	0.052
>10,000 baht	68.33	79	60	66	1.00	
Median (IQR)	15,000 (14,790)	15,000 (8,488)	15,000 (19,000)	15,000 (20,250)		
BMI (%)						
Low (<25 kg/m^2)	68.33	66	69	70	1.04 (0.64-1.70)	0.854
Normal (25-30 kg/m^2)	24.67	22	27	25	1.00	
High (>30 kg/m^2)	7.00	12	4	5	0.41 (0.17-1.00)	0.050
Mean (±SD)	23.64±0.24	23.66±4.53	23.66±3.75	23.62±4.05		
Alcohol consumption (%)						
Never	69.33	69	74	65	1.00	
Former	15.33	13	12	21	1.58 (0.86-2.89)	0.137
Current	15.33	18	14	14	0.85 (0.47-1.54)	0.601
Smoking status (%)						
Never	84.67	92	86	76	1.00	
Former	12.00	8	10	18	2.23 (1.15-4.35)	0.018
Current	3.33	0	4	6	4.30 (1.27-14.57)	0.019
Diabetes (%)						
No	91.00	100	90	83	1.00	
Yes	9.00	0	10	63	4.80 (2.19-10.50)	<0.001
Category II: Signs and symptoms						
Bleeding gums (%)						
No	54.67	61	66	37	1.00	
Yes	45.33	39	34	63	2.11 (1.38-3.24)	<0.001
Receding gums (%)						
No	58.67	73	62	41	1.00	
Yes	41.33	27	38	59	2.78 (1.80-4.31)	<0.001
Tooth mobility (%)						
No	62.33	93	62	32	1.00	
Yes	37.67	7	38	68	8.94 (5.43-14.73)	<0.001
Dental calculus (%)						
No	23.57	34	25	12	1.00	
Yes	76.33	66	75	88	2.51 (1.52-4.14)	0.001

Red and swollen gums (%)						
No	65.33	81	72	43	1.00	
Yes	34.67	19	28	57	3.84 (2.41-6.13)	<0.001
Food impaction (%)						
No	48.67	58	56	32	1.00	
Yes	51.33	42	44	68	2.21 (1.45-3.38)	<0.001
Tooth movement (%)						
No	64.00	75	67	50	1.00	
Yes	36.00	25	33	50	2.31 (1.48-3.60)	0.001
Sore gums (%)						
No	65.67	80	71	46	1.00	
Yes	34.33	20	29	54	3.30 (2.08-5.24)	<0.001
Tooth sensitivity (%)						
No	34.00	39	38	25	1.00	
Yes	66.00	61	62	75	1.59 (1.03-2.47)	0.065
Malodor (%)						
No	35.00	51	27	27	1.00	
Yes	65.00	49	73	73	2.29 (1.46-3.60)	<0.001
Do you think you have periodontitis? (%)						
No	63.00	87	66	36	1.00	
Yes	37.00	13	34	64	6.00 (3.72-9.67)	<0.001
Category III: Oral hygiene care						
Toothbrushing frequency (%)						
1 time/day	4.00	2	5	5	3.18 (1.05-9.62)	0.042
2-3 times/day	82.00	62	75	78	2.20 (1.33-3.65)	0.002
>3 times/day	4.00	36	20	17	1.00	
Toothpick use (%)						
No	68.67	60	76	70	1.44 (0.91-2.27)	
Yes	31.33	40	24	30	1.00	0.056
Dental flossing (%)						
No	49.33	31	53	64	2.77 (1.80-4.26)	
Yes	50.67	69	47	36	1.00	<0.001
Single tuft use (%)						
No	91.33	92	93	89	1.00	
Yes	8.67	8	7	11	1.35 (0.63-2.87)	0.662
Proxabrush use (%)						
No	82.00	85	85	76	0.62 (0.36-1.08)	
Yes	18.00	15	15	24	1.00	0.093
Mouthwash use (%)						
Never/ Sometimes	81.33	88	79	77	0.59 (0.34-1.00)	
>1 times/day	18.67	12	21	23	1.00	0.049
Category IV: Dental history						
Dental check-up frequency (%)						
<1 times/year	40.67	30	37	55	2.22 (1.44-3.42)	
≥1 times/year	59.33	70	63	45	1.00	0.001
Extraction from periodontitis (%)						
No	74.00	94	77	51	1.00	
Yes	26.00	6	23	49	6.21 (3.66-10.55)	<0.001
Dentist told you that you have periodontitis (%)						
No	68.33	90	72	43	1.00	
Yes	31.67	10	28	57	5.91 (3.60-9.71)	<0.001

Dentist told you that you have pocket depth or bone loss (%)						
No	77.33	91	79	62	1.00	
Yes	22.67	9	21	38	3.66 (2.16-6.20)	<0.001
Dentist told you that you need periodontal treatment (%)						
No	75.00	92	82	51	1.00	
Yes	25.00	8	18	49	6.28 (3.64-10.84)	<0.001
Root planing in the past (%)						
No	82.33	91	84	72	1.00	
Yes	17.67	9	16	28	2.76 (1.56-4.87)	0.002
Gum surgery in the past (%)						
No	90.00	97	89	84	1.00	
Yes	10.00	3	11	16	2.93 (1.44-5.97)	0.005
Denture wearing (%)						
No	81.67	91	79	75	1.00	
Yes	18.33	9	21	25	2.20 (1.28-3.77)	0.006

Predictive model development

Multivariable ordinal logistic regression analysis was performed to obtain the final predictive model. The set of variables in the final model with significant predictive ability for the severity of periodontitis consisted of age 40-54 years (OR=3.63, 95% CI=1.91-6.90, $p<0.001$), age >54 years (OR=9.13, 95% CI=4.74-17.56, $p<0.001$), male (OR=1.93, 95% CI =1.14-3.26, $p=0.014$), bleeding gums (OR=1.92, 95% CI=1.13-3.25, $p=0.016$), tooth mobility (OR=4.82, 95% CI=2.72-8.55, $p<0.001$), patients who thought they had periodontitis (OR=2.31, 95% CI=1.27-4.21, $p=0.006$), patients who did not use dental floss (OR=2.18, 95% CI=1.29-3.66, $p=0.003$), dental check-up < 1 time/year (OR=1.93, 95% CI=1.14-3.28, $p=0.015$), and periodontitis diagnosis by a dentist (OR=2.73, 95% CI=1.44-5.16, $p=0.002$) (Table 3).

Scoring system and cut-off points

Each β-coefficient was divided by the least value of the β-coefficient of the model (e.g., bleeding gums: 0.65) to obtain the transformed score. Then, each transformed score was rounded up or down to the nearest 0.5. For our predictive model, the derived item scores ranged from 0 to 3.5 and the total score ranged from 0 to 13 (Table 3). The total score was calculated in each group of patients with no/mild, moderate, and severe periodontitis. The median (Interquartile range: IQR) total scores in each group were 2 (2), 5.5 (3.25), and 8.5 (3.5), respectively.

To obtain the most effective cut-off points, we calculated the performance of scores which were the most correctly predicted and least over or underestimation from several cut-off points that are likely to be able to differentiate each disease severity group.

The most effective cut-off points for our predictive model were scores 4.5 and 7. Total scores less than 4.5 correctly predicted no/mild periodontitis in 85 patients (28.3%) with an underestimation in 29 patients (9.7%). Total scores from 4.5 to 7 correctly predicted moderate periodontitis in 45 patients (15%) with an underestimation in 29 patients (9.7%) and an overestimation in 10 patients (3.3%). Total scores greater than 7 correctly predicted severe periodontitis in 67 patients (22.3%) with an overestimation in 35 patients (11.7%) (Table 4).

Overall, these cut-off points predicted periodontal status correctly in 197 patients (65.7%) with an underestimation in 58 patients (19.3%) and an overestimation in 45 patients (15%). The obtained scores discriminated

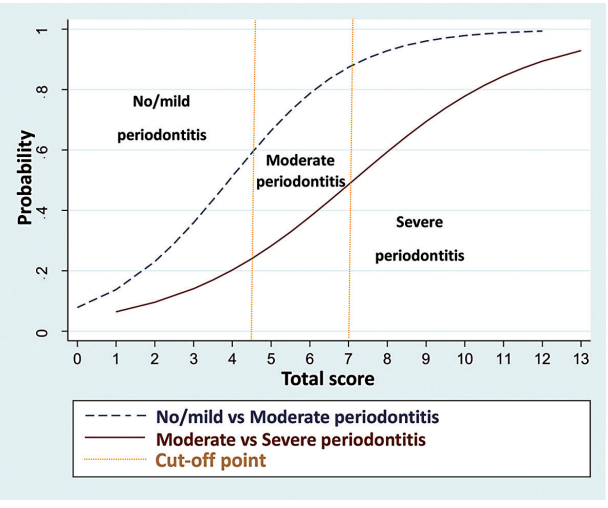

Figure 1: Discrimination of periodontitis severity scores.

Table 3: Significant predictors of periodontitis severity and assigned scores

Predictor variable	Adjusted OR	95% CI	*p* value	β-coefficient	Transformed Score	Assigned Score
Age						
<40 years	1					0
40-54 years	3.63	1.91-6.90	<0.001	1.29	1.98	2.0
>54 years	9.13	4.74-17.56	<0.001	2.21	3.4	3.5
Gender						
Female	1					0
Male	1.93	1.14-3.26	0.014	0.66	1.02	1
Bleeding gums						
No	1					0
Yes	1.92	1.13-3.25	0.016	0.65	1	1
Tooth mobility						
No	1					0
Yes	4.82	2.72-8.55	<0.001	1.57	2.42	2.5
Do you think you have periodontitis?						
No	1					0
Yes	2.31	1.27-4.21	0.006	0.84	1.29	1.5
Dental flossing						
No	2.18					1
Yes	1	1.29-3.66	0.003	0.78	1.2	0
Dental check-up frequency						
<1 times/year	1.93					1
≥1 times/year	1	1.14-3.28	0.015	0.66	1.02	0
Dentist told you that you have periodontitis.						
No	1					0
Yes	2.73	1.44-5.16	0.002	1.00	1.54	1.5

Table 4: Predicted periodontitis severity and predictive validity

Predicted periodontitis severity	Total score	Periodontal case definition (CDC-AAP)			Predictive validity		
		No/mild (n=100)	Moderate (n=100)	Severe (n=100)	Over (%)	Correct (%)	Under (%)
No/mild (n=114)	<4.5	85	25	4	-	85 (28.3)	29 (9.7)
Moderate (n=84)	4.5-7	10	45	29	10 (3.3)	45 (15)	29 (9.7)
Severe (n=102)	>7	5	30	67	35 (11.7)	67 (22.3)	-
				Total	45 (15.0)	197 (65.7)	58 (19.3)

among the three severity groups of periodontitis, as shown in figure 1.

Predictive validity

Our predictive tool discriminated moderate and severe periodontitis from no/mild periodontitis with an AuROC of 0.92 (95% CI;0.89-0.96), with the specificity of 85%, and the sensitivity of 85.5%. To distinguish severe periodontitis from no/mild and moderate periodontitis, the value of the AuROC was 0.88 (95% CI;0.84-0.92) with the specificity of 83.5%, and the sensitivity of 67% (Figure 2).

Discussion

The prediction of periodontitis based on a set of self-reported questions has been demonstrated to be more accurate than those based on a single question.[7,23,24] For this reason, we employed this method combined with demographic and risk factors in this study. In order to create a set of predictive model questions, multivariable ordinal logistic regression was performed. Among eight

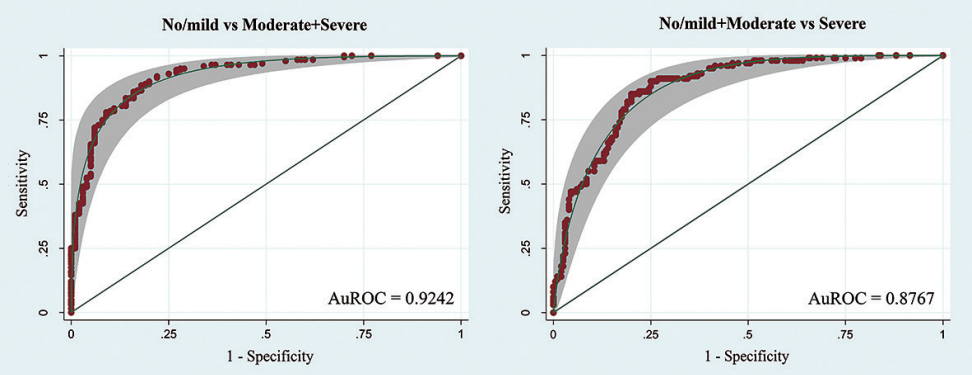

Figure 2: AuROC for periodontitis case definition purposed by CDC-AAP. (Left: AuROC for moderate and severe periodontitis, Right: AuROC for severe periodontitis)

significant variables in our final model, age and tooth mobility were the most influential factors in predicting the severity of periodontitis.

Among demographic variables, age and gender were the only two significant variables included in our final model. These two variables were also included in previous predictive models.[6,11,12,14,17] Moreover, age and gender were identified as the risk indicators in the Thai study group according to the study by Torrungruang *et al.,*[25] The results of our study assure that the combination of demographic features in the predictive model can improve the accuracy of the model as shown in previous studies.[7,23,24]

As for signs and symptoms, bleeding gums and tooth mobility were two self-reported variables that can predict the severity of periodontitis. Particularly for tooth mobility, our statistical analysis showed that the adjusted odds ratio for the severity of periodontitis was 4.82 (95%CI = 2.72-8.55), which reinforces the strong influence of this variable. According to a systematic review by Abbood *et al.,*[9] tooth mobility was a highly accurate predictor for severe periodontitis defined by the CDC-AAP criteria. In addition, tooth mobility is a good indicator of severe periodontitis, as it is a simple clinical feature that both dentists and patients can correctly identify.[7,15,26] As such, it was not surprising that this predictor would regularly remain in the predictive model for periodontitis in various studies.[10,14,17] From the results of our study, bleeding gums were also a good predictor, as reported by previous studies.[11,16,21] However, one should realize that a sign of bleeding gums is not always associated with chronic periodontitis but indicates active gingivitis.[27]

In our present study, dental flossing was the only variable in the oral hygiene care category that predicted the severity of periodontitis. This result is in line with the study conducted by Cepeda *et al.,*[28] which proved the association between dental flossing and a low prevalence of periodontitis in an American population. Moreover, this variable has also been included in many final models.[6,14,15]

In the dental history category, the influential variables were dental check-up frequency, diagnosis by a dentist, and individual assessment of periodontitis. To answer these questions effectively, the participants must have had dental examinations in the past.[7,9] In this study, only 6.33% of patients had never received any dental services. Therefore, most patients were expected to be able to report their dental history efficiently in our study. This factor probably accounts for the existence of these variables in our final model.

Smoking and diabetes are certain risk factors for periodontitis, as confirmed by previous studies[27,29-32] In our findings, both smoking and diabetes had a statistically significant correlation with the severity of periodontitis only in the univariable analysis model. Perhaps, this is due to the low incidence of smokers and diabetics in our study population, causing our model to be underpowered in predicting the disease. In fact, the result was similar to the study of Cyrino *et al.,*[15] in a Brazilian population.

Globally, the predictive ability of self-reported models has been determined by values of the sensitivity, specificity, and AuROC. According to the validity classification of the self-assessment model proposed by Nelson *et al.,*[32] the predictive ability was evaluated using

values of the sensitivity and specificity, which were defined as low (<60%), moderate (60-79%), or high (≥80%). In addition, Swets[33] assessed the model performance based on the AuROC, which was defined as low (0.5-0.7), moderate (0.7-0.9), or high (>0.9). Referring to the aforementioned studies, some other studies[10,12-15,19] usually obtained the AuROC of the predictive model in a range of 0.79-0.94. Regarding the specificity and sensitivity, while one value was moderate or high, the other was low or moderate. In this study, when using the above criteria, the periodontitis screening model was found to have high accuracy in discriminating moderate and severe periodontitis from no/mild periodontitis with an AuROC of 0.92 (95% CI=0.89-0.96), with a specificity of 85% and a sensitivity of 85.5%. The ability of the predictive model to discriminate severe periodontitis from no/mild and moderate periodontitis was fair with an AuROC of 0.88 (95% CI=0.84-0.92), with the specificity of 83.5%, and the sensitivity of 67%. It can be noted that the model has a higher validity in predicting moderate and severe periodontitis than severe periodontitis. This result is consistent with our focus on using the model to screen the disease in patients from the early stages of the disease. This can lead to an in-time treatment process that reduces the rate of tooth loss from periodontitis.

Our study has strengths and limitations. For strengths, firstly, this study provided a methodology for evaluating the disease using the widely accepted CDC-AAP criteria for epidemiological research in periodontitis.[34] These criteria were combined with full-mouth examination at six sites of teeth, which is the "gold standard" measurement.[35] In addition, the periodontal assessments were performed by a trained dentist and calibrated by two periodontists. All of these helped to reduce the chance of misdiagnosis. Secondly, in the study, several question variables relating to periodontitis were applied to identify a set of good predictors effectively. Moreover, to our knowledge, this is the first periodontitis predictive model in a Thai population that implements the scoring system alongside applicable recommendations. Meanwhile, for limitations, the study population was who received dental care at the Faculty of Dentistry, which is considered a convenient sample. Our samples may not represent the Thai population as a whole. More than half of the participants had high education and income level, and nearly all of them had dental care experience before participating in this study. Prevalence of smoking and having diabetes were low, which were acknowledged as strong risk factors for periodontitis. Thus, the final model may be influenced, and the generalizability of the study results may be limited.

The periodontitis screening model that we have developed may be utilized as a clinical disease screening tool, or for the epidemiological surveillance of periodontitis. In order to achieve external validity, a similar study in a more extensive and diverse population should be conducted. Moreover, this model should be further analyzed for its usage in other populations.

Clinical implications

Our main objective was to develop a simple screening tool for patients to conduct a preliminary periodontitis evaluation for themselves. To achieve this goal, a scoring system was developed. It predicted the severity of periodontitis with 65.7% accuracy, underestimated (false negative) by 19.3%, and overestimated (false positive) by 15%. The false negative should be as low as possible in order to warn patients with periodontitis. However, patients in each severity group should be given suitable but different recommendations as follows:

1) No/mild periodontitis (scores<4.5): Patients in this group tend to have little or no noticeable symptoms of periodontitis. Even so, regular individual oral hygiene is still necessary. Visiting the dentist twice a year for plaque removal and oral check-up are also needed. In addition, treatment planning for this group is usually not complicated, and a high success rate of treatment is to be expected,

2) Moderate periodontitis (scores 4.5-7): Patients in this group may need to be treated by a periodontist. They need not only scaling and root planing, but maybe also periodontal surgery. Assessment of risk factors for periodontitis is recommended. After complete treatment, the patients are highly recommended to see a periodontist according to their individual needs, in order to maintain good periodontal status,

3) Severe periodontitis (scores>7): Patients in this group should immediately see a periodontist to assess the periodontal condition and to receive proper treatment, due to the possibility of tooth loss. Most of such patients require complex treatment procedures or even a plan for denture placement.

Conclusions

Our periodontal disease screening tool demonstrates adequate accuracy and represents a promising tool for predicting periodontitis in a Thai study group. The predictive model has high accuracy in discriminating between moderate and severe periodontitis. We have identified age and tooth mobility as the most powerful question variables in the model. Our developed scoring system shows the potential to classify patients into three severity groups of periodontitis, as defined by the CDC-AAP criteria. The validation of this model should be further investigated in a more extensive and diverse population.

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Conflicts of interest

The authors declare no conflicts of interest.

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Case Report

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Case Report: Prosthesis (Complete Denture) for Communication and Behavioral Impaired Dementia Patient

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Abstract

Aim: To describe the procedures for complete denture fabrication in dementia and behavioral impairment patient and how to manage the case holistically.

Methods and Results: The patient was a 77-year-old woman diagnosed with moderate dementia, Alzheimer's disease with Behavioral and Psychological Symptoms of Dementia. The patient lost her previous complete dentures. She had signs of agnosia, communication problems and behavioral control. These aspects increased the difficulty in her daily life activities and in providing dental treatment. Our goal was to restore her oral function and to improve her overall general health by fabricating new complete dentures. An online consultation was used to oversee the behavioral management, adaptation in posture, and techniques in prosthodontic procedures between the postgraduate dental student providing this treatment and the prosthodontic specialist in an academic institute while they were in different places. The dental treatment in this case was provided holistically and patient-centered, the dental treatment outcomes were achieved through the follow-up visits.

Conclusions: This case study revealed that a dementia patient could receive appropriate dental treatment in cooperation with the care team to maintain her oral health function. Behavioral management could be performed using non-pharmacological methods. After delivering the denture, the patient's nutritional status and the quality of life largely depends on the caregiver when the dementia progresses.

Keywords: Alzheimer's disease, behavioral management, caregivers, complete denture, holistic health

Introduction

Alzheimer's disease (AD) is a progressive neurodegenerative brain disorder responsible for 60-80% of dementia cases in elderly people.[1] The clinical characteristics of dementia typically begin with subtle/poorly recognized memory failure (Mild Cognitive Impairment or MCI), slowly become more severe, and eventually incapacitating.[2] Most individuals with dementia experience progressive cognitive decline and non-cognitive symptoms, such as various Behavioral and Psychological Symptoms of Dementia (BPSD). BPSD comprises many symptoms that may be expressed at all dementia stages. Agitation, apathy, altered sleep patterns, depressive behavior, and aberrant motor behavior are examples of BPSD.[3] Worldwide, females are more prone to AD than males, and the risk increases with age.[4] The more severe the stage, the greater the dependency level in AD patients. This can cause stress and psychological morbidity in caregivers; behavioral symptoms and impairment in daily living activities in AD patients are associated with caregiver stress.[5] The main causes of death of an AD patient are general infection, malnutrition, pneumonia, or dehydration.[2]

The dental treatments for moderate to severe stage dementia patients are difficult to perform due to the progressive cognitive decline that alters their cooperation and behavior while receiving dental procedures. Although the decision making in providing prosthodontic dental treatment to dementia patients is challenging, the patient's oral health-related quality of life needs to be considered because there are many psychosocial aspects that contribute to it. When appropriate dental management increases the patient's quality of life as best that it can, it is important to maintain the oral health function until the end stage of dementia occurs.

Materials and Methods

A 77-year-old Australian female diagnosed as AD with BPSD by an Australian psychologist, was referred from an adult care facility to the Intercountry Centre for Oral Health (ICOH) dental clinic in Chiangmai for a new denture. The totally edentulous patient had lost her previous complete denture approximately 5 months prior to her visit. In 2016 when she was diagnosed with early onset of dementia Alzheimer's type, her family took care of her until the dementia symptoms declined and the family could not provide her the appropriate care. Her family decided to move her to the care resident in Chiang Mai, Thailand for appropriate long-term stay in 2017.

The first few years as an in care resident, the patient lived alone in a house located on the grounds of the care facility. She did not require full time nursing care and did not have a specific caregiver but shared one with other residents. The caregivers at the facility are registered nurses. They provided care for each resident according to their Activity of Daily Living (ADL) score. The patient in this report required major assistance for complex tasking or the IADL (Instrumental Activity of Daily Living), such as making a phone call, playing a board game, doing exercises, or going out of the care residence, however she could perform other ADL, such as showering, dressing, eating, and walking, by herself. Furthermore, she could wear and take care of her old dentures by herself without any complaint. She usually took the dentures out at night and placed them in a glass of water in her bathroom, while the nurses found many dental adhesive tubes around her house.

In May 2020, a nurse noticed that she was eating without her dentures. However, the patient was not aware of this problem. In addition, the patient did not eat or drink during the daytime. Therefore, after she lost her dentures, her body weight decreased by 5 kilograms over five months. Her face and body appeared to be neglected as her symptoms of dementia progressed. Her family and caregiver were concerned about her health and nutritional status, thus, they sought dental treatment to fabricate new dentures for the patient. In addition to her physical health, when she did not have her denture, her mental health and quality of life were also reduced.

Due to the patient's uncontrolled and aggressive behavior, we needed a well-designed treatment plan. The patient's care was provided by one of the authors (PG) under the direction of the Geriatric Dentistry and Special Patient Care program, Faculty of Dentistry, Chulalongkorn University. After gathering the patient's history and performing her examination, we used an online platform via text/picture/video chat messages and real-time VDO calls for consulting and discussing this case. Thus, real-time consultation during treatment was used to provide the appropriate management and the outcome was reviewed while we were in different locations.

At the first dental visit, the patient came to the ICOH dental clinic with a young nurse assistant who was not fluent in English. The patient appeared moody and frustrated about visiting the clinic. Her appearance and clothes were neglected. (Figure 1) We performed an oral examination and observed the patient's behavior and communication skills. Because her main caregiver did not accompany her, the patient's history was taken by interviewing the caregiver by phone call on the first visit. Based on the patient's comprehension and behavior, we requested the main caregiver to come with the patient for the subsequent dental visits.

Figure 1: On the first dental visit the patient was moody and frustrated. Her appearance and clothes were neglected.

The extraoral examination revealed that the patient had an ovoid facial shape with a slightly concave lateral facial profile. The temporomandibular joint examination indicated no significant pathological deviation. The intraoral examination revealed high and well-rounded totally edentulous maxillary and mandibular ridges. There was no sign of infection or inflammation in the oral cavity. The tongue and oral mucosa were clean and moist.

Due to her AD symptoms, she was confused and disoriented. Her past medical history comprised hypertension, osteoarthritis of the neck and spine, clavicular fractures, and pancreatitis. Her only current medication was Seroquel XR, an antipsychotic medicine, 50 mg, ½ tab at breakfast and 1 tab at bedtime. Her Barthel Activity of Daily Living (ADL) score was 12, which indicated a totally dependent status. Her Mini Mental State Examination (MMSE)[7] score was 11-13 out of 30, defined as moderately cognitive impairment. We evaluated her clinical frailty as moderately frail[8]; although she could walk without a cane or wheelchair, she needed assistance for all outside activities. Considering her behavioral and psychological symptoms, she had a history of aggressive behavior, mood swings, depression and sleep disturbance at night.

The patient had difficulty in speaking when we asked her questions; she had delayed responses and could not understand long or complex questions. Her responses were brief and repetitive. Sometimes she refused to follow the requests or orders and would not cooperate during simple procedures, such as taking the preliminary impression, which is a critical procedure for fabricating a complete denture.

The dental treatment plan was discussed with her main caregiver and the family abroad. The final decision was made after we evaluated the patient and discussed the case online. The main caregiver, who was a registered nurse and was fluent in English accompanied her for her dental treatment in the subsequent visits.

On the second visit the upper arch preliminary impression was performed. The patient could not tolerate the alginate impression material texture. She had a severe gag reflex when we delivered the tray with impression material into her mouth. Furthermore, she pulled the tray and material out before it set. On the third and fourth visit, we positioned the patient to sit on the dental bed to reduce the gag reflex, then used fast-set alginate with warm water to reduce the setting time. Managing her behavior and moods using a clear voice tone, eye contact, and gentle hand-restraining by her caregiver and a dental assistant helped the patient calm down and be more cooperative. Using these methods, we obtained an appropriately detailed impression; the upper arch impression had some defects in the tuberosity and anterior portion, while the lower arch impression had good detail. We used this impression for the master model. (Figure 2)

We had difficulty trying in the upper arch occlusion rim. The patient experienced the gag reflex soon after we placed it in her mouth. Therefore, the posterior border of the upper arch acrylic rim was shortened before try in. (Figure 3)

After the modification, the patient cooperated throughout the procedure. The level and contour of the bite block were measured, the midline and canine line were

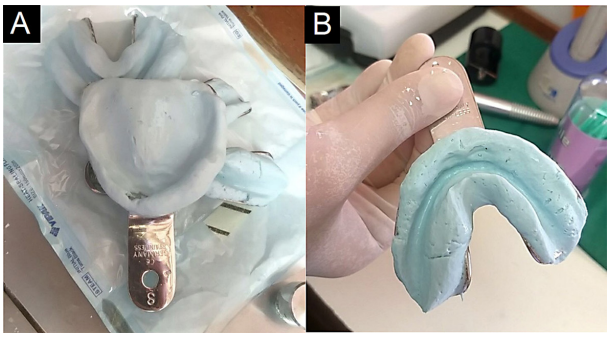

Figure 2: The preliminary impression that we use as the final impression. The upper arch (2A) and the lower arch (2B).

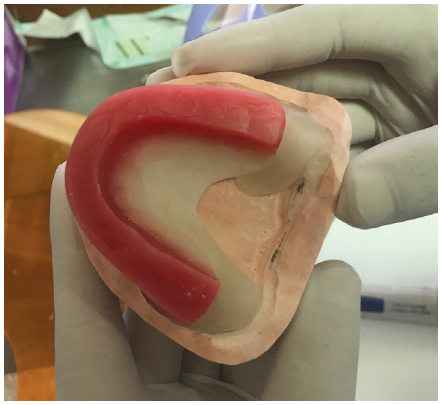

Figure 3: We shortened the posterior border of the upper arch occlusal rim for the try in.

marked. Subsequently, wax bite registration material was used for recording the jaw relation. The patient was asked to watch and follow the dentist. The vertical dimension was determined until it reached the appropriate height. The denture teeth were arranged using non-anatomic teeth to reduce lateral interference. The esthetic try-in and jaw relation verification was done using a trial denture. Due to the midline shift, the jaw relation record was re-verified with vinylpolysiloxane bite registration (Blu-moose®, parkell®, Edgewood, NY, USA) to consume lesser time. The upper denture palate portion was waxed up to regain full palate coverage. Both dentures were fabricated using high impact resin. Although the upper denture was slightly loose, the lower denture had good retention and stability. The tissue surface and denture border were evaluated with pressure-indicating paste (Keystone, Gibbstown, NJ, USA). Occlusal correction was performed intraorally to eliminate occlusal interferences.

Denture cleansing tablets were prescribed to improve the denture's hygiene. The importance of prosthesis hygiene and removing the prosthesis at bedtime was emphasized to the caregiver. The patient was appointed for follow-up visits to evaluate and adjust the denture as needed. The summary of the treatment processes, the problem list, and the solution strategy are shown in Table 1.

Results

After delivering the dentures, the patient could wear the dentures and remove them by herself. However, the patient hesitated to wear the dentures, especially the upper denture because it was slightly loose and stimulated her gag reflex. During the occlusal adjustments, we used a temporary dental adhesive to make the denture stable in her mouth. After two weeks, the patient adapted herself to the new dentures. We subsequently applied Dynamic Impression Lining material (DIL: KAMEMIZU®, Osaka, Japan) on the upper denture border that acted as the functional impression material, which began auto-curing 3-5 d after lining. This step helped the patient to become more comfortable with her denture, while improving the denture retention and stability.

The caregiver was the key person who supported the patient to wear the denture. One month after denture delivery, the patient refused to wear the dentures all the time except at mealtimes. Due to the worsening of her AD symptoms, she required a private nurse 8 h. a day. The denture together with encouragement from the caregiver improve the quantity and quality of the meals and she gained 4 kg after 3 months. Her appearance and mood also greatly improved. (Figure 4)

Figure 4: The patient at the 1-month recall.

Table 1: The workflow of the treatment processes, the problem list, and the solution strategies.

Visit	Duration	Clinical treatment	Problems list	Solving strategies
1	90 mins	- History taking - Extra-intraoral examination	- Patient could not retrieve self-information - Uncooperative behavior	- Interviewed the keyperson which is the main caregiver who responsible to the care of patient - Cooperated with the specific caregiver who can manage patient's behavior - Prepared the dental clinic environment to be quiet, calm and pleasant
2	45 mins	Take 1st preliminary impression	Uncooperative behavior: pull the impression tray out before the impression material were set due to high gag reflex	- Scheduled the dental treatment to coincide with regularly scheduled antipsychotics drug or morning schedule within 2-3 hours after wakeup - Short-visit appointment - Fast-set impression material and warm temperature water - Behavioral management: non-verbal communication; eye contact and gentle touch - Adjusted patient to upright position during procedure - Cooperated with the main caregiver and dental assistant to distract patient while waiting the impression to set - Desensitized with hand pumping in the impression material prior the dental impression
3	45 mins	Take 2nd preliminary impression		
4	45 mins	Take 3rd preliminary impression		
5	45 mins	Try in occlusion rim	The distal part of palatal plate of upper occlusal rim provokes the gag-reflex.	- Cut the distal part on upper of occlusion rim in horse-shoe shape
6-7	60 mins	Verified vertical dimension	Patient could not bite in the same position.	- Trained the patient to bite by tell-show-do technique and repeated it over - Short intervals visit between 6th and 7th visit
8	60 mins	Try in teeth	The baseplates are loose.	- Used the temporary dental adhesive
9	45 mins	Denture delivery	- The upper denture got loose - Patient could wear dentures for a period and took it off by herself.	- Used the temporary dental adhesive for making it stable in the mouth for occlusal adjustment - Convinced patient to wear denture and emphasized the main caregiver to supervise and checking the oral mucosa if there was any redness or ulcer before seeing the dentist in next visit
10	30 mins	Recheck 1 week	Could not retrieve signs and symptoms for adaptation after denture delivery because patient refuse to wear denture.	- Emphasized the caregiver to supervise the patient to wear denture at mealtime and collect patient's symptoms after denture were used by interviewing the main caregiver
11	45 mins	Recheck 2 weeks	The upper denture got loose.	- Used DIL for relining material
12	45 mins	Recheck 1 month	DIL got hardening and had porosis tend to get denture stomatitis.	- Adjusted tissue surface of denture to remove porous and spicules - Emphasized OHI to the caregiver

Discussion

Most individuals with dementia suffer progressive cognitive decline and non-cognitive symptoms, such as behavioral changes.[3,9] Therefore, simple dental procedures cannot be performed easily due to the patient's confusion, disorientation, and mood changes. Non-pharmacological interventions were used in this case rather than medication or sedation due to their side effects, such as increased confusion, increased fall risk, drowsiness, and dizziness.[10]

A caregiver with good communication skill plays an important role in receiving dental treatment and daily life activities for the patient. Good communication, including explaining in detail with simple words about the dental procedures, can reduce the patient's confusion while gaining trust during the process. According to the House Mental Classification System of Denture Patients,[11] the patient and/or their family factor are the importance factors that need to be evaluated before providing the treatment.

The main position of the patient during the procedures was upright on the dental bed. For the occlusion recorded, wax bite registration material was used due to its accuracy and reusability.[12] Blu-Mousse®, which is fast-setting and user friendly, is also the material of choice despite its price for dementia patients who experience disorientation and restlessness. The zero-degree artificial teeth were used to avoid lateral interference.[13]

DIL, composed of chemically-cured poly (ethylmethacrylate) and polyfunctional methacrylate, was used to improve the retention of the upper denture.[14] After mixing and placed intraorally, the DIL gradually adjust itself to the shape of the edentulous ridge and mucosa, then fully polymerizes after one week. The DIL was used as a long-term permanent material that should be replaced every 6 months.

In this case we used behavior management and communication strategies by always approaching the patient from the front. A person who is familiar with the patient, or the patient trusts should always be present during the treatment sessions. The dentist used short and simple words when talking to the patient. A slow, clear, and low voice tone was used. Sometimes the sentences or instructions were repeated and we waited for the patient's response. Eye contact, smiling, and gentle touches raised the trust between the dental personal and the patient. The empathy that the clinician and other dental personals showed to the patient markedly improve the patient's trust. Non-verbal communication, i.e., body language, was very important, the patient could better perceive intension non-verbally.[14] Uncooperativeness can occur during a dental procedure because of patient mistrust and the unfamiliar environment. A quiet dental clinic environment and music therapy can create calm and positive behavior in dementia patients.[12]

Our clinical observations revealed that the patient adapted to the new denture more easily than we expected. Her past denture experience might have shortened the adaptation period, also she had not gone long without her dentures. A previous study found that there was a significant correlation between the ability to wear and remove the denture and the ADL score and the dementia severity level, however, age was not correlated with this ability.[13-14] The factors relating to denture wearing were being able to communicate, wear clothes, eat, wash, get up from a chair or bed, and the number of remaining teeth.[4] Therefore, maintaining the ADL level is important.

The prosthodontic process for CD fabrication does not require too much patient cooperation, which allows for achieving a good outcome without invasive behavioral management. In contrast, if a dementia patient has some remaining teeth in their mouth, some procedures, such as tooth preparation, placing a restoration, water suctioning, or other steps that produce an unexpected sound or pain, this may trigger uncooperative and aggressive behavior. In that circumstance, medication or conscious/nonconscious sedation may provide the appropriate management rather than non-pharmacological methods.

When a patient's dementia condition worsens, the oral health related quality of life still needs to be considered because there are many psychosocial aspects to contemplate in addition to eating and nutrition, such as appearance and communication. Indeed, we continued to see these improvements during the follow-up visits. A prior study found that higher dependency rates in elderly individuals are correlated with the likelihood to receive less dental care.[4] Therefore, we encourage this high dependency group to receive more appropriate oral care from a dental professional team or at least proper oral awareness and care from their caregiver.[15]

There should be dental service in elderly homes providing scheduled dental visits to the residentials.

Dental service in a familiar and relax environment elderly home will reduce the confusion and increase the positive behavior of dementia patients. The recall or maintenance service of oral health is also very important in older adults, especially for those in a high dependency group. Tele-medicine and teledentistry can contribute to the general and oral health of dependent patients by improving and continuing their medical and dental support. In addition, this tele-communication will reduce inequity in care access especially in frail people who cannot reach health services.

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