

Development And Validation of an Interprofessional Dental Ergonomics Educational Module for Implementation into Dental Curriculum

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ABSTRACT

INTRODUCTION: Musculoskeletal diseases (MSDs) are associated with prolonged uncomfortable postures and repetitive actions. The purpose of this study was to develop and validate a structured interprofessional dental ergonomics (IDE) module that could be added to the dental curriculum to address these issues. **MATERIALS AND METHODS:** The study comprised three phases: i) Needs assessment, ii) Instructional module development, and iii) Validation. Guidelines, relevant literature, and the findings of the needs assessment served as the foundation for the ergonomic module development, which comprised 6 units: i) human factors and ergonomics, ii) basic dental ergonomics, iii) operator positioning, iv) dental team ergonomics, v) workstation design, and vi) ergonomic practices like working smart and short breaks. The module content validity index and reliability were evaluated and verified by 7 experts. 103 dental professionals represented by 42 dental practitioners, 35 dental students, and 26 faculty members, completed a self-administered questionnaire on IDE. **RESULTS:** Overall, 87% of respondents valued microbreaks, 92% strongly agreed that ergonomics should be taught in schools, and 57% said that MSDs affected their day-to-day job. The expert panel firmly agreed that the module could improve knowledge and that it was acceptable. The module's good content and face validity were supported by the validation findings. **CONCLUSION:** The developed IDE module demonstrated both useful content and face validity. Dental students' knowledge, comprehension, and skills to prevent MSDs can be improved by incorporating this into dentistry education, supporting better health and well-being.

KEYWORDS: Musculoskeletal disorders (MSD), Centre for Disease Control (CDC), National Institute of Occupational Health (NIOSH), Sustainable Development Goal 3 (SDG-3), ADDIE model.

INTRODUCTION

The core responsibilities of dental professionals include promoting oral health and delivering high-quality dental care in a safe clinical setting. Dentists are often required to perform precise and delicate procedures within confined spaces of the oral cavity on patients who may be tense or anxious. These demanding clinical conditions frequently compel dentists to work in awkward postures and sustain prolonged muscular strain. Consequently, numerous studies have reported a high prevalence of musculoskeletal disorders (MSDs) among dental practitioners.¹⁻⁶ According to the World Health Organization (WHO), MSDs are conditions affecting the muscles, tendons, peripheral nerves, or vascular structures that do not arise from a single acute or traumatic event (e.g., slip or fall). These disorders are considered work-related when occupational

factors significantly contribute to their development, even when they represent only one component of a multifactorial aetiology.^{7,8}

Among the MSD types that dental professionals report most often are back, neck, shoulder, hand, and wrist problems (carpal tunnel syndrome, Guyon's canal syndrome, de Quervain's tenosynovitis, and trigger finger).⁶ As a dentist enters the workforce, they must manage complex organisational environments and assume leadership roles within dental teams, in addition to applying patient care based on clinical skills acquired during undergraduate training. Dental students' education must include a substantial emphasis on ergonomics to prepare them for their future employment. Numerous topics in the dental curriculum must be covered to gradually advance students' education.¹⁰ Ergonomics is the science of creating a workplace and job criteria that consider the abilities of the working population. When properly applied, dental ergonomics ensures a notable reduction in the prevalence of MSDs among dentists.^{9,10}

This study sought to create and assess a structured and validated Interprofessional Dental Ergonomics (IDE) module to guarantee the integration of successful preventive measures against musculoskeletal disorders (MSDs) in dental practice. An interprofessional team of 2 dental educators, 1 occupational therapist, 1 physiotherapist, and 1 ergonomics specialist worked together to create this module, for incorporation into the dental curriculum. To ensure alignment with precisely stated educational objectives, the development process adheres to the ADDIE instructional design methodology.

MATERIALS AND METHOD

To create an interprofessional dental ergonomic (IDE) module that can be incorporated into the dental curriculum, this study used the ADDIE model as a module development design methodology. The analysis, design, development, implementation, and evaluation phases are the five stages of the ADDIE module development design paradigm that was employed in this investigation.

In the analysis phase of the ADDIE model, a needs analysis questionnaire⁴ was used to determine if there is a need to develop a module on dental ergonomics. A pilot study was conducted with 25 dental students through purposive sampling to validate the questionnaire before conducting the investigation. The 5-member interprofessional experts examined the face validity of the questionnaire, and modifications were made in response to their suggestions.

For the design phase of the ADDIE model, the needs analysis questionnaire administered in the previous analysis phase was analysed to determine the development needs of the IDE module and the topics in the ADDIE-based IDE module. For the development phase, the ADDIE-based IDE module was constructed based on the main components analysis resulting from the needs analysis questionnaire administered in the previous analysis phase. Lastly, for the evaluation phase, the validity, reliability, and usability of the developed module were analysed.

Phase I ADDIE: Needs Analysis for the development of IDE module

The need analysis questionnaire focused on i) age, ii) sex, iii) year of study, iv) health issues they believed were related to their employment as dentists (caused/aggravated/maintained), v) questions about knowledge

(awareness of MSDs due to dental practice, dental ergonomics, ergonomic exercises, and ergonomic operator stool), vi) questions about attitude (attending workshops on dental ergonomics and adhering to ergonomic principles), vii) questions about practice focused on ergonomic principles while treating patients in clinical practice, viii) how many hours they worked in the clinic each day, and ix) whether they were left- or right-handed. The purpose of the survey was explained to the participants, and only those who indicated interest were included. Informed consent was obtained before the start of the study.

The face validity of the questionnaire was examined by the 5 interprofessional experts, and modifications were made in response to their suggestions. Modifications were incorporated based on their feedback to enhance the instrument's validity before pilot testing. Following internal consistency testing, the Cronbach's alpha (α) value was 0.87.

Phase II ADDIE: Design and Development of the IDE module

Module design was thoroughly examined and debated by 7 core committee members of the research team which included; 3 administrators of JSS Dental College and Hospital (2 dentists, 1 chief operational officer for dental equipment), and 4 interprofessional mentors from the Foundation for Advancement of International Medical Education and Research (FAIMER), MAHE MFILIFE, (1 orthopaedist, 1 physiotherapist, 2 public health dentists).

Module Design

The material of the module was developed using several guidelines, pertinent literature, and additional domestic and foreign sources.^{11,12} The module was also updated to include data gathered from the needs assessment.

This IDE module was designed to enhance ergonomic competence, occupational health, and clinical efficiency among dental professionals. The programme comprised 6 integrated modules that combine theoretical foundations with applied clinical practice. The initial modules introduce key concepts of human factors, biomechanics, and ergonomic principles, emphasizing the influence of human capabilities and limitations on dental performance. Subsequent modules focused on musculoskeletal risk assessment, the neutral working position, and ideal operator posture to minimize physical strain and optimize workflow efficiency. The curriculum further explored the role of dental auxiliary staff, four-handed dentistry, and team communication in fostering ergonomic collaboration. Attention is also directed toward the ergonomic design of dental workstations, equipment layout, and space utilization to reduce occupational hazards. The concluding module integrates performance management strategies and preventive exercises aimed at promoting long-term practitioner well-being and professional sustainability. A blended instructional approach comprising lectures, demonstrations, case scenarios, and group discussions ensured comprehensive learning and skill development. Collectively, the programme aimed to cultivate a culture of ergonomic awareness, reduce the prevalence of work-related musculoskeletal disorders, and enhance overall productivity and safety in dental practice. Table I summarizes the IDE module content. All the modules will be delivered via i) lecture series (PowerPoint presentation), ii) demonstration, iii) videos, iv) case scenarios, and v) group discussion.

Phase III ADDIE: Evaluation of the interprofessional dental ergonomic module

The module was evaluated in 5 sections and 20 items: i) aims; ii) content; iii) language and format of the module; iv) presentation; and v) usefulness of the module. The module validator scores were based on the 5 criteria.

Each item in every section was rated on a four-point relevance scale; 4: very relevant, 3: relevant, 2: somewhat relevant, and 1: barely relevant. The scientific accuracy of the content was evaluated based on 2 factors: i) the extent to which the data were consistent with established evidence, and ii) the degree to which the recommendations were relevant and appropriately addressed.

Table I: Summary of Interprofessional Dental Ergonomics Educational Module

Module Topics	Contents	Learning objectives
Topic 1: Human factors and ergonomics	Biomechanics of the human body	1. Define key concepts of human factors and ergonomics and explain their relevance in the dental setting
	Review of musculoskeletal hazards in dentistry	
	Control of working motions' efficiency	2. Identify and analyse the human capabilities and limitations (physical, cognitive, and organizational) that impact system design and performance.
	Problems related to spine and neck in dentistry	
	Basic understanding of dental ergonomics	
Topic 2: Basic understanding of Dental ergonomics	Dimensions of dental ergonomics	1. Defining dental ergonomics and explaining their importance in promoting occupational health and clinical efficiency.
	Identification of risk factors	2. Understanding the impact of repetitive motions and static postures in dental settings and how to mitigate them.
		3. Concept of the neutral working position (NWP) and its relevance in daily dental practice.
		4. Basic ergonomic principles were applied to evaluate and improve clinical working habits.
	Ideal operator working posture and its components as applied in dentistry.	5. Recognize early signs and symptoms of musculoskeletal strain and understand the importance of early intervention.
Topic 3: Ideal operator positioning	Ergonomic workplace assessment	1. Describe the principles of proper operator and patient positioning to reduce physical strain during dental procedures.
		2. Demonstrate correct posture and positioning techniques for various dental procedures using ergonomic guidelines.
	Role of the chair-side dental assistant	3. Evaluate workplace systems and environments to identify ergonomic risks and opportunities for improvement.
		4. Describe the primary responsibilities of a chairside dental assistant in clinical and patient-care settings.
		5. Proper techniques for instrument transfer, suctioning, retraction, and patient management during dental procedures.
Topic 4: Dental auxiliary staff and dental team	Four-handed	6. Identifying the ergonomic benefits of effective chairside assistance for both dentists and assistants.
		7. Recognize the role of the assistant in infection control and aseptic techniques, including the preparation and sterilization of instruments.
	Time management	8. Understanding how to assist patient positioning to ensure comfort and optimal access to the operator.
	Team building and effective interprofessional communication	9. Impact of a competent chairside assistant on the overall quality of dental care and patient experience.
	Topic 5: Designing of Dental workstation	The dental furniture and equipment selection and maintenance
Dental delivery systems and space utilization.		2. Apply ergonomic principles to design tasks, tools, equipment, and workspaces to enhance safety, comfort, and performance.
Performance management		3. To apply time management and organizational skills in preparing and maintaining the operatory before, during, and after procedures
Topic 6: Working Smart and Working Right.	Chairside Operator Exercise	4. Recognize the role of teamwork and communication in enhancing individual and team performance.
		5. Identify the role of equipment design and layout (e.g., dental chair, hand instruments, lighting) in minimizing ergonomic hazards.
		6. Apply strategies for continuous professional development and self-assessment in dental practice.
		7. Incorporation of stretching and micro-break exercises in clinical routines to prevent musculoskeletal disorders.
		8. Simulate realistic clinical scenarios that require coordination between dentists and assistants in a time-efficient and ergonomic manner.

Phase IV and V ADDIE:

During the implementation and evaluation phase, the complete module was analysed to determine the validity, reliability, and usability of the IDE module. To validate the learning module, the Instructional Material Evaluation Instrument developed by Castro et al.¹³ was implemented. SPSS version 26 was used to perform statistical analysis. Cronbach's alpha (α) was used to confirm the questionnaire's internal consistency.

RESULTS

Phase I ADDIE:

A self-administered questionnaire on interprofessional dental ergonomics (IDE) was completed by 103 dental professionals, represented by 42 dental practitioners (DP), 35 dental students (DS), and 26 faculty members. Even though dental students are not considered as dental professionals or practitioners, they were included in the requirements assessment to represent future members of the dental workforce and provide insights into ergonomics-related educational and training deficiencies within the dentistry curriculum. Their involvement allowed for a comprehensive understanding of ergonomic practices and knowledge among teachers, practitioners, and students at different phases of professional development. Only responses from faculty members and licensed dental practitioners were categorised under professional specialisations for specialty-based analysis to maintain categorisation accuracy.

The study cohort was predominantly right-handed (96% of participants). In terms of dental occupational status, dental practitioners constituted the largest subgroup (45% of participants). Consistent with general occupational musculoskeletal complaints, pain experienced during work was most reported in the neck and back regions. Figure 1 illustrates the varying mean intensities of pain across the body. The back region reported the highest mean pain intensity (mean=2.65), followed by the neck (mean=2.37).

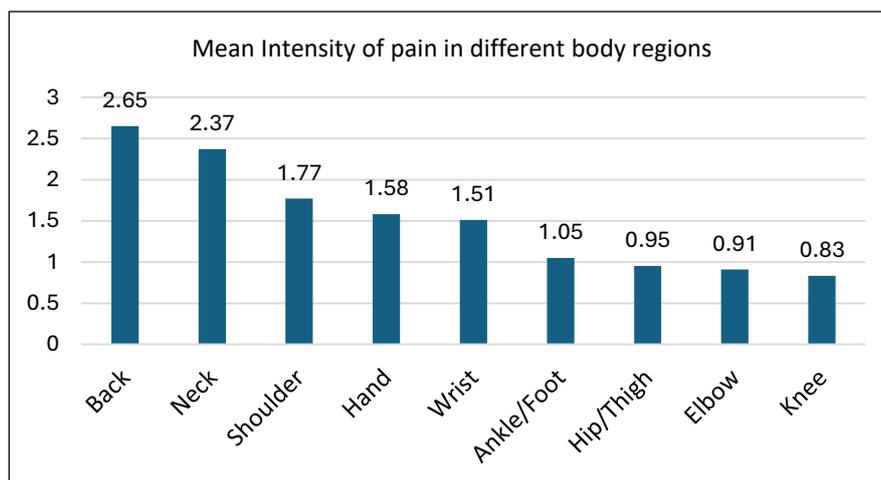


Figure 1: Mean pain intensity in different body regions (n=103)

A comparison across the dental occupational categories revealed significant differences in pain intensity (Figure 2). The back remained the region with the highest mean pain intensity across all three dental occupation status, reaching its peak intensity among dental students (DS) (mean=2.9). Overall, dental students consistently reported the highest mean pain intensities across body regions, most notably the back, neck, and shoulder. Conversely, the lowest recorded mean pain intensity was observed in the knee region for

all three dental occupation status (mean=0.7). 94% of the respondents believed that undertaking a dental procedure aggravated musculoskeletal problems, and 57% felt that these problems impacted daily activities. There was a strong consensus (92%) that ergonomic principles should be emphasized in the curriculum, and 87% agreed on the importance of microbreaks. Awareness of ergonomic practices varied, with 65% never performing chair-side exercises. Notably, 72% defined ergonomics as measures for optimizing work and health, but only 14% consistently apply ergonomic postures, with 50% citing distractions or difficulties.

Phase II and III ADDIE: Design and Development of IDE module

The need evaluation served as a signal to develop a pertinent body of knowledge regarding the dental ergonomics module. The entire module was examined and graded by a panel of experts. Because each expert gave the elements a meaningful evaluation (on a scale of 3 or 4), the materials within the module were deemed legitimate. The content validity evidence can be represented by the content validity index (CVI). For the sake of CVI computation, the scales of 3 and 4 were combined into a single group. Cronbach's alpha (α) for the 20 items in the module, evaluated by seven experts, was 0.97, indicating a very high degree of internal consistency. Excellent reliability is typically shown by a Cronbach's alpha (α) value above 0.90, indicating that the scale's items are closely associated and accurately assess the same underlying construct. Table II shows the validation of the Interprofessional Dental Ergonomics education module.

Table II: Validation of the developed Dental Ergonomic module ($\alpha=0.969$)

Criteria	Items	Relevant	I-CVIs
Module objectives	The objectives were clearly stated.	3	1
	The objectives are well-planned, formulated and organized	4	
	The stated objectives were specific, measurable, and attainable.	4	
	The objectives are relevant to the topics of each module	4	
	The objectives considered students' and clinicians' needs.	4	
Module content	The content of each chapter is directly relevant to the defined objectives	3	0.97
	The content of each chapter is clear and easy to understand	4	
	The topics of these chapters have been fully discussed.	4	
	The topics are supported with illustrative examples, and confirm to the level of the students' understanding	3	
	Each topic is given equal emphasis in each module	4	
Module format and language	The language used is easy to understand	3	0.92
	The language used was clear, concise, and motivational.	4	
	The modules were presented in a unique and original order.	3	
Module Presentation	The writing activities are clearly presented.	4	1
	The presentation of each chapter is interesting and attractive to students.	3	
	Each section contains sufficient examples.	4	
Module usefulness	The module will help students master the topics for spirituality care rendered to patients	4	1
	The module will help students master the topics, to improve their health, which fosters quality care rendered to patients	4	
	The module will allow students to select dental equipment	4	
	This module is expected to develop students' critical thinking and collaboration skills.	4	

Phase IV and V ADDIE: Implementation evaluation of the IDE module

The 7-member expert panel reviewed and rated the entire module. All experts rated the items as relevant; the relevance rating was recoded as '1' (relevance scale of 3 or 4) or '0' (relevance scale of 1 or 2). However, minor revisions were required for those with an initial scale of 3. These revisions were considered to improve certain parts of the module. These included the following: i) rephrasing a few confusing statements, ii)

including additional statements for further clarification, and iii) improving the graphic images of the presentation slides. Improvements to the module and materials were made accordingly. Two forms of content validity index (CVI) were calculated, which were i) item-level content validity index or I-CVI, and ii) scale-level content validity index or S-CVI. The I-CVI indicated the proportion of content experts giving the item a relevance rating of 3 or 4. The S-CVI based on the average method refers to the average of I-CVI scores for all items on the scale or the average of proportion relevance judged by all experts.

The overall content validity results for each expert, with their agreement percentage indicating an acceptable agreement with the contents of the module. The data provided indicates that most experts strongly agreed with most aspects of the module and instructor assessments. Specifically, all the experts strongly agreed on the academic proficiency of the instructor, the effectiveness of the module content in increasing knowledge, its relevance to organisational needs, and overall satisfaction. For other aspects, 53.3% of the expert panel members strongly agreed on the ability of the instructors to engage learners, respond to ambiguities, and the current relevance of the module. This suggests a generally high level of satisfaction with slight variations in specific areas, indicating areas for potential improvement. All the items assessed had acceptable values of agreement greater than 0.83 based on Lynn.¹⁴ Table III tabulates the content validity index evaluation for the Interprofessional Dental Ergonomic (IDE) module by a 7-member expert panel.

Table III: Content validity index evaluation for Interprofessional Dental Ergonomic module by 7-member expert panel.

Module Items	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert Agreement	I-CVI
Content									
Item 1	1	1	1	1	1	1	1	7	1
Item 2	1	1	0	1	1	1	1	6	0.85
Item 3	1	1	1	1	1	1	1	7	1
Item 4	1	1	1	1	1	1	1	7	1
Item 5	1	1	1	1	1	1	1	7	1
S-CVI									0.97
Format and Language									
Item 1	1	1	1	1	1	1	1	7	1
Item 2	1	1	1	1	1	1	1	6	0.85
Item 3	1	0	1	1	1	1	1	6	0.85
Item 4	1	1	1	1	1	1	1	7	1
S-CVI									0.92
Usefulness									
Item 1	1	1	1	1	1	1	1	7	1
Item 2	1	1	1	1	1	1	1	7	1
Item 3	1	1	1	1	1	1	1	7	1
S-CVI									1
Presentation									
Item 1	1	1	1	1	1	1	1	7	1
Item 2	1	1	1	1	1	1	1	7	1
Item 3	1	1	1	1	1	1	1	7	1
S-CVI									1

I-CVI = item-level content validity index
 S-CVI = scale-level content validity index

All experts agreed that the course content significantly enhances students' knowledge, indicating high relevance and educational value. The course directly supports organisational goals, confirming its practical and applied focus. The course content aligns well with defined learning objectives, showing coherent instructional design. 58% of the experts strongly agree, and 42% showed average agreement, indicating a strong consensus among

experts that the module is effective, relevant, and well-structured. Table IV shows the assessment of IDE content validity by a 7-member expert panel.

Table IV: Assessment of Interprofessional Dental Ergonomic module content validity by a 7 - member expert panel.

Module Content	Assessment Scale	n (%)
Course content assessment Effectiveness of the contents of the course in increasing your knowledge	Strongly Agree	7 (100)
Course content assessment Relationship between training course and your organizational needs	Strongly Agree	7 (100)
Course content assessment Up-to-datedness of the contents of the course	Strongly Agree	4 (57.1)
Each topic is given equal emphasis in each module.	Strongly Agree	4 (57.1)
The content of each chapter is directly relevant to the defined objectives	Strongly Agree	4 (57.1)
	Agree	3 (42.9)
The content of each chapter is clear and easy to understand	Strongly Agree	4 (57.1)
	Agree	3 (42.9)
The topics of chapters are fully discussed.	Strongly Agree	4 (57.1)
	Agree	3 (42.9)
The topics are supported with illustrative examples, and confirm to the level of the students understanding	Strongly Agree	4 (57.1)
	Agree	3 (42.9)
The chapters of the module are presented in a unique and original order.	Strongly Agree	4 (57.1)
	Agree	3 (42.9)
The presentation of each chapter is interesting and attractive to students.	Strongly Agree	4 (57.1)
	Agree	3 (42.9)
Each chapter is provided with sufficient examples.	Strongly Agree	7 (100)
The module will help students master the topics.	Strongly Agree	7 (100)
The module will allow students for selection of dental equipment	Strongly Agree	4 (57.1)
	Agree	3 (42.9)
The module is expected to develop students' critical thinking and collaboration skills.	Strongly Agree	4 (57.1)
	Agree	3 (42.9)

DISCUSSION

One of the primary reasons for adding an ergonomic training module to the dental curriculum is the prevalence of work-related musculoskeletal disorders (MSDs) among dental students and practitioners. Dental practice involves awkward placement, repeated motions, and prolonged static postures, all of which can lead to chronic pain and damage, particularly in the shoulders, back, and neck. Students who received early and structured ergonomic training were significantly less likely to develop these occupational health issues because they were able to recognize and adopt appropriate work habits and postures.¹⁵⁻¹⁷

Ergonomic modules also highlight the need for teamwork, patient positioning, and clinical environment organization to deliver safer and more effective dental care. In addition to protecting themselves, students who receive instruction in these areas enhance patient comfort and safety during treatment.^{15,16} To reduce work-related musculoskeletal problems among dental professionals, the current study focused on the creation and evaluation of a dental ergonomic educational module. Dental professionals and ergonomic experts concur that training is essential for developing healthy stereotypes and achieving an appropriate working posture.

The goals of ergonomics instruction were to enhance attitudes for identifying and avoiding risk factors in dental practice through self-assessment of the working posture and a critical view of the overall organisation of the working process, implement a positive interest in establishing an ergonomically friendly clinical learning

setting, and design an educational module of dental ergonomics that provides sound fundamental knowledge and tools for efficient and injury-free work that increases productivity and improves quality of life.

Content Validity of the Interprofessional Dental Ergonomic Teaching Module Based on the ADDIE Model

Module development is guided by various models. The production of the IDE module is guided by an adaptation of the ADDIE paradigm, which has been utilised in other research to create educational modules.¹⁸ Specific learning objectives, learning outcomes, resources, assessment criteria, and evaluation should all be included in the development of any educational module.¹⁹ These elements were added to the IDE module to provide users with a complete experience. This study offers the first IDE module that has been properly developed and validated.

The 7-member expert agreement was indicated by the findings of the content validity analysis of the ADDIE-based teaching and learning module. The language used in the IDE module was clear and appropriate for the students' level of proficiency. The findings of the ADDIE-based IDE educational module's content validity analysis are congruent and align with the findings of another study,²⁰ which created a STEM-based teaching module and achieved high content validity scores. The next question that needs to be addressed is whether the ADDIE model-based DE module is appropriate in terms of dependability. Based on the analysis, Cronbach's alpha = 0.969, which suggests a high degree of reliability for the IDE module created.

CONCLUSION

Within the limitations of the study, the IDE module was developed based on the ADDIE model and demonstrates potential for implementation across most dental institutions, subject to available resources and infrastructure. Integrating the module into both theoretical instruction and practical clinical workflows may equip graduates with the knowledge, skills, and professional competencies required for safe and effective patient care. Furthermore, early incorporation of this IPE module into dental curricula, including during mannequin-based training may contribute to the prevention of work-related musculoskeletal disorders among dentists. It is hoped that the findings of this study will support the relevance and applicability of the IDE module and convince the regulatory bodies such as the Dental Council of India or the National Dental Council (NDC) for the benefit of dental students and faculty.

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