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Original Article

Acceptability of interactive post-endodontic restoration decision making application among undergraduate dental students

Jia Qing Soo [a], Xing Yong Wong [a], Naveen Chhabra [a*], Liang Lin Seow [a], Shekhar Bhatia [b]

[a] School of Dentistry, IMU University, Kuala Lumpur, Malaysia
[b] School of Dentistry, University of Queensland, Brisbane, Australia

Abstract *Background/Purpose:* Selecting an appropriate coronal restoration after root canal treatment requires careful consideration, however, there is a lack of established web-based tool that is based on clear guidelines for suitable post-endodontic restorations. Hence, we aimed to design and determine the acceptability of an interactive application to aid the decision making process for post-endodontic restoration among the undergraduate dental students.

Materials and methods: A web-based post-endodontic restoration decision making interactive application, (*RestoSmart*) was developed after a detailed review of available literature. Seventy undergraduate dental students of IMU University were recruited in the study. A validated questionnaire was given to the participants before and after the use of *RestoSmart* to answer the provided mock clinical scenarios. Obtained data were statistically analyzed using IBM SPSS version 26 software package.

Results: The statistical analysis demonstrated that *RestoSmart* was acceptable among the undergraduate dental students ($P < 0.05$). Initially, participants recognized the potential benefits of designing an interactive application, 74% believing that it may enhance decision making and 76% emphasizing its user-friendliness. Additionally, close to half of the participants expressed the willingness to use interactive tools in future. Following the use of *RestoSmart*, there was a notable increase in favorability, with 94.2% finding it helpful in the decision making and 94.3% acknowledging its user-friendliness. Furthermore, 87.2% expressed intent to use *RestoSmart* in future.

Conclusion: RestoSmart was useful for decision making and user friendly. While overall response was positive, there exist some areas for improvement such as ease of use, updating evidence-based guidelines, and establishing its helpfulness in teaching and learning.

 * Corresponding author. School of Dentistry, IMU University, 126, Jln Jalil Perkasa 19, Bukit Jalil, Kuala Lumpur 57000, Federal Territory of Kuala Lumpur, Malaysia.
 E-mail address: naveenchhabra@imu.edu.my (N. Chhabra).

Introduction

Like any other treatments, post-endodontic restoration decisions rely on evidence-based knowledge, weighing its risks and benefits, and taking potential outcomes into account.[1] This is crucial in root treated teeth as access preparation often results in considerable loss of tooth structure in already weakened tooth, leading to significant biomechanical alterations,[2–5] diminished integrity of tooth structure[6] and higher risk of fractures.[4] An excellent coronal seal, preservation of the remaining tooth, restored function, and aesthetically pleasing results are necessary for the successful restoration of root treated teeth.[7] Therefore, appropriate decision making for the post endodontic restoration, in particular selecting a suitable coronal restoration, must be given thoughtful evidence-based considerations.[8] However, there are differences in knowledge, skills and experience among the operators that greatly affects post-endodontic restoration decision making.[9–11] Furthermore, based on Sequeira-Byron et al., there are lack of defined guidelines on the most ideal definitive restoration after root canal treatment, especially regarding teeth that require cuspal coverage and optimal type of restoration.[12] Hence, developing a standardized guide for post-endodontic restoration decision making will certainly provide the evidence-based and informed decision making amongst dental practitioners as well as dental students. Additionally, compiling the evidence-based data in the form of a web-based application could further expedite the post-endodontic restoration decision making.

Looking at how the recent Covid-19 pandemic led to an inevitable surge in the use of digital technologies due to the loss of face-to-face teaching,[13] we decided to design an interactive application that could serve as a justifiable guide in the decision making process for post-endodontic restorations. This interactive tool includes fundamental criteria and variables, clinically acceptable measurements, and a computerised quantification system, which is expected to be more practical and user-friendly.[9] Additionally, it is web-based, which can be used across a variety of platforms as well as gadgets, and be easily distributed, managed and updated.[9]

Before designing the application, we aimed to consider numerous aspects during the selection of suitable coronal restorations for endodontically treated teeth. To understand the rationale behind choosing a restoration for teeth post-endodontically, we carried out extensive literature searches using various scientific online search engines as well as offline. Based on Bhuva et al., we found out that various operative and patient factors have to be taken into account as root filled teeth are affected by complex and diverse structural and biomechanical considerations.[8] These combined factors play vital role in the survival of the restoration and tooth, nevertheless, it is impossible to quantify the relative contribution of each variable although the loss of sound tooth structure appears to be the most crucial contributory factor.[14]

By applying the concept of utilizing a web-based tool to assess the endodontic case difficulty by Shah et al., we aimed to develop an interactive application that involves series of questions which are simple, reliable and could help undergraduate dental students in making decisions in the provision of post-endodontic restoration and study the acceptability of such tool.[9]

Material and methods

This analytical case study model involved detailed review of literature and thorough analysis to develop the interactive application.

The development of interactive tool was guided by the IMU e-Learning department. A wireframe of the application was planned using Microsoft PowerPoint followed by mockup. A series of specific questions pertaining to the factors governing the post-endodontic restoration selection were determined to be included in the web-based application. Once the wireframe was finalized, the Microsoft Power App (Microsoft Inc, Redmond, WA, USA) was used to develop a web-based interactive application, named as *RestoSmart* (Fig. 1).

IMU University students from Year Four and Five BDS program were recruited in the study. Year Four and Year Five students were included as they are allowed to carry out root canal treatment and post endodontic restoration in clinical settings. Hence, they have the necessary foundational knowledge to aptly assess the mock clinical cases and evaluate functionality of *RestoSmart* application. The minimum required sample size was calculated using the Cochran formula, which is commonly used in any prevalence and population-based study which will give a desired level of precision, desired confidence level, and the estimated proportion of the attribute present in the population. Assuming there were 96 undergraduate dental students in IMU that were able to carry out root canal treatment procedures in undergraduate clinics, the minimum required sample size was 77 with 95% confidence level, margin of error of 5% and estimated population proportion of 50%. However, out of 77, 70 participants responded to our questionnaire, giving 91% response rate.

For evaluation of the designed interactive tool, ten representative mock clinical case scenarios were selected from previously treated clinical case databases followed by validation from four endodontists and four prosthodontists. Each mock case included information about the tooth number, probing depth, mobility, tenderness to percussion, amount of tooth structure removed, root canal geometry, presence of ferrule, root length and aesthetic concern. Clinical images and radiographs were provided to
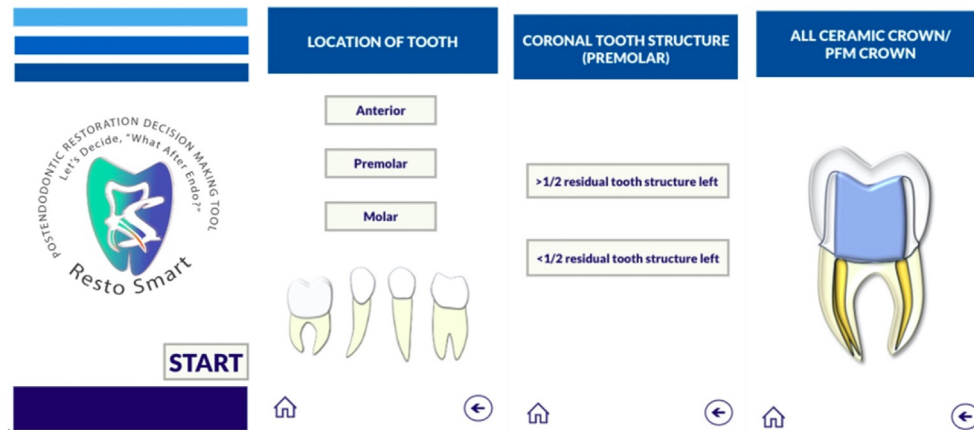
Figure 1 *RestoSmart* interface displaying certain assessment criteria.

participants. Participants were instructed to use *RestoSmart* to complete 2 randomly selected mock cases before submitting their overall feedback. A representative mock case and the recommended treatment option by *RestoSmart* is shown in Fig. 2.

To understand the acceptability of *RestoSmart* in assisting the decision making process of post-endodontic restoration, participants were required to answer the similar set of questionnaires consisting of 6 close-ended questions before and after using *RestoSmart*. Participants were advised to complete 2 test cases using *RestoSmart* before submitting their overall feedback. The questionnaire covered parameters such as the helpfulness in decision making, ease of use, likelihood of using the decision making application tool in the future, evidence-based nature, user-friendliness and helpfulness in teaching and learning.

The test cases and questionnaires were validated in two phases. Firstly, content validation was performed by sending the test cases and questionnaire draft to four endodontists and four prosthodontists to examine whether the test case scenario and questions are appropriate, identify ambiguity, lack of clarity, or bias in questions drafting. Feedback from the panel led to minor revisions in wording to ensure comprehensive coverage of the constructs. Thereafter, a pilot study was carried out through a convenient sample of five undergraduate dental students to ensure understanding of the contents and process by the participants.
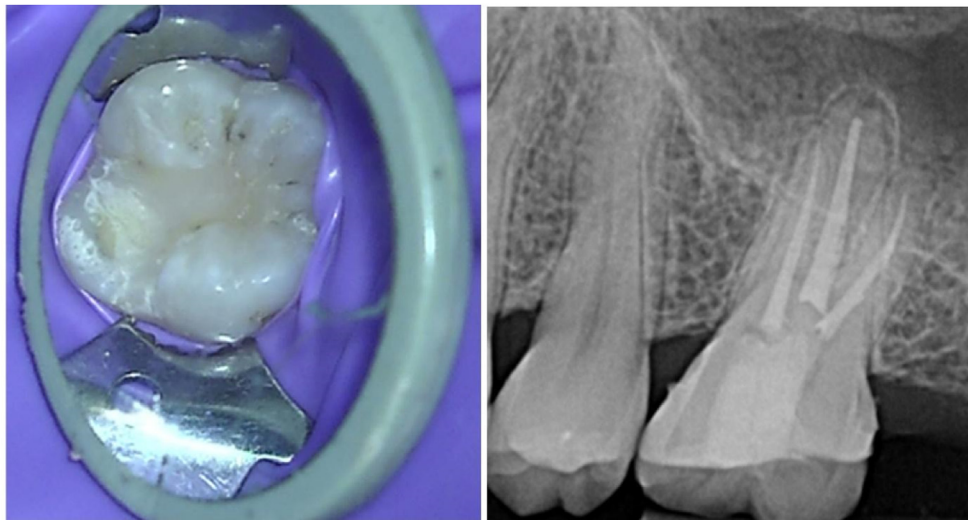
Representative mock case scenario

A male aged 45 years comes with the chief concern of restoring the upper back tooth which was endodontically treated 3 months earlier. Upon clinical examination, #26 is restored with composite with all 4 walls remaining. Periodontal probing shows 2 mm probing depth, no mobility, and no tenderness to percussion at # 26.

Definite post-endodontic treatment recommendation: onlay

Figure 2 Representative mock case scenario utilized for testing web-based application tool (a) Clinical picture (b) Radiographic representation of the case.

The questionnaires were distributed for a period of six weeks which included instructions, test cases, hyperlink to *RestoSmart*, and the questionnaires. Participant information sheet was provided to the students to obtain consent for participating in this study, the form was electronic based, Google Forms (Google LLC, Mountain View, CA, USA) and distributed online through WhatsApp (WhatsApp Inc, Menlo Park, CA, USA) as well as email. The Google form setting 'limit to 1 response' was switched on to avoid duplication of responses.

The collected questionnaire responses were coded, cleaned, and analyzed using absolute frequencies by utilising IBM SPSS version 26 software package (IBM Corp., Armonk, NY, USA), followed by data interpretation in the form of frequency and proportion by using Wilcoxon-Signed Rank Test which is a non-parametric statistical test. From the questionnaire responses, the user experience and relevance were determined by measuring different parameters. Analysis of the comments highlighting the potential improvements will be incorporated into the next version of the interactive tool.

Results

The results collected prior to using *RestoSmart* revealed that the majority of the participants already acknowledged the potential advantages of incorporating interactive tool in decision making for restorative treatments. Prior to using the interactive application tool, the pre-test result indicated 74% of the participants believed that such a tool would aid in their decision making, highlighting an inclination of undergraduate dental students towards digital solutions. Apart from that, 76% of the participants emphasized the importance of user-friendliness, reflecting that they prefer tools with simple interfaces. Furthermore, 47% expressed their willingness to use this application in future, showing a readiness to embrace innovative solutions in the learning process.

After using *RestoSmart* and subjected to the same questionnaire (post-test), there was significant increase in favorability among the participants. 94.2% participants agreed with the helpfulness of *RestoSmart* in assisting the decision-making processes and 94.3% of participants recognized the user-friendliness of this application, suggesting that *RestoSmart* has met their usability expectations. Moreover, 87.2% of participants expressed their intent to use *RestoSmart* in the future (Table 1).

Although there was an overall positive response of *RestoSmart*, there are certain aspects where *RestoSmart* can be improved. Especially, there were no significant results observed in terms of ease of use, evidence-based nature, and helpfulness in teaching and learning after participants' trial of *RestoSmart*. This indicates potential

areas where *RestoSmart* may fall short in meeting the comprehensive needs of users, particularly in terms of providing clear justifications for recommended restoration options, offering alternative options for consideration, and incorporating references to support decision making processes. Addressing these aspects of improvement suggested by participants will make *RestoSmart* more acceptable by users.

The power of study was calculated to be 0.75, with a 75% chance of correctly detecting a true effect if it exists.

Discussion

Recently, online learning has become more significant in both medical and dental education.[15-19] However, healthcare education faces significant challenges, such as emphasizing and standardizing competencies and learning outcomes, integrating formal knowledge with clinical experience, focusing on patient-centred care, population health, cost-conscious high-value care, and understanding the organization of health services.[20] Nevertheless, digital learning is now an essential component of contemporary instruction.[13] The use of technology in healthcare education has become increasingly prevalent, offering numerous educational advantages, such as enhanced and realistic visualisation, standardized instruction, evidence-based decision making, and an authentic context for learning for better clinical outcomes. Additionally, computer technologies can assess competencies and milestones, providing students with the tools to continue accessing necessary clinical knowledge to deliver quality care and remain lifelong learners.[20]

Participants were in favor of *RestoSmart*'s helpfulness because it has the ability to recommend suitable post-endodontic restoration options based on key parameters such as tooth location, remaining tooth structure, aesthetic requirement, presence of heavy occlusal forces or limited interocclusal space, canal geometry, presence of ferrule and post length.[21] Hence, this tool is able to provide tailored recommendations based on individual cases. Apart from that, *RestoSmart*'s user-friendly design, featuring interactive elements, a minimalist interface, visually appealing and simplified line diagrams, was well-received. The incorporation of customised figures enhanced user engagement and aided in understanding complex concepts such as residual tooth structure and ferrule. Additionally, using mobile applications in clinical settings is highly beneficial, as they distribute standardized knowledge among students and are more ergonomic compared to desktops.[22] *RestoSmart* also received a welcoming response of likelihood to use in the future as it aligns with the growing trend of using digital technologies while having positive effects on learning as shown in a study by Christoph

Table 1	Test statistics.					
	Helpfulness	User friendliness	Use in the future	Ease of use	Evidence based nature	Helps in teaching and learning
P-value	<0.001	<0.001	<0.001	0.006	0.112	0.851
% (pre)	74.2	75.7	47.1	85.7	91.4	90.0
% (post)	94.2	94.3	87.2	95.7	90.0	91.4

et al. (2022).[13] *RestoSmart* offers a convenient aid for post-endodontic restoration decision making by including the fundamental criteria. Furthermore, by summarizing essential considerations, the tool streamlines the decision making process, thereby saving time.

A key question for mobile health apps is, "What makes a good health app?" Currently, there isn't a comprehensive way to understand and evaluate the various aspects of mobile health apps. Typically, validation is specific to one app in a particular field and focuses on assessing its usability.[23] More clinical scoring systems are being developed that include functions like determining endodontic diagnoses, evaluating the complexity of endodontic cases, calculating drug dosages, and measuring root canal lengths. These apps can quickly provide information, but their accuracy needs to be confirmed to minimize errors.[24]

Likewise, we have identified several opportunities to enhance *RestoSmart*. Many participants found the tool useful, though some encountered challenges in understanding certain parameters, affecting its ease of use. This was particularly evident when assessing subjective factors, such as the amount of remaining tooth structure left (less than or more than half). There is also a need to assess the thickness of the remaining walls. The lack of clinical images made it challenging to visualize clinical circumstances based only on clinical descriptions and radiographs. Additionally, some users had different interpretations of specific aspects, such as canal geometry (elliptical or circular), highlighting the need for further explanations with figures, and including live clinical scenarios within *RestoSmart*. The incorporation of 3D live clinical scenarios is very important as based on the study carried out by Vagg et al. (2020), students have shown the greatest interest in incorporating 3D animations, interactive 3D teaching tools, and simulators into their studies, believing these elements would have a substantial impact on their learning experience.[25]

Participants also suggested including more references for recommendations, with justifications and providing alternative treatment options. Participants' feedback presents valuable opportunities to enhance the evidence-based decision making within the tool. A study by Chiappelli et al. has emphasized the need for detailed explanations and evidence-based references to improve the reliability and trust in clinical recommendations provided by such tools.[26] While the current version relied on literature reviews and specialist recommendations, limited by development constraints, it is encouraging to know that these enhancements are planned for future updates, promising a more robust and comprehensive tool.

Moreover, *RestoSmart* can improve in supporting teaching and learning as some users expressed a desire for specialist opinions for personalized feedback on post-endodontic restoration, given the many clinical variables involved. They preferred not to rely exclusively on the interactive tool.[27] This feedback highlights the potential to enhance the tool by adding features that improve users' comprehension and educational experience. One effective improvement could be a feature that allows multiple users simultaneously, so that specialists can have online discussion with the users within *RestoSmart* itself. According to Nadershahi et al., a key recommendation for educational innovation involves incorporating active learning techniques to enhance student engagement and learning.[28] This would help users better understand the decision making process and enrich their educational experience with valuable insights into alternative options. Overall, while *RestoSmart* shows great potential for assisting in decision making, implementing these enhancements will be key to increasing its utility and favorability in the future.

The trial version of the *RestoSmart* had very limited features as it was self-developed seeking minimal support from technical experts. For example, the incorporation of advanced features such as, incorporating inbuilt camera feature that may assist in recording live video or photo of actual tooth to aid in real time restoration decision making. Hence, future version of the app can be designed utilizing advanced software tools by collaborating with experts in technical field.

This study showed significant acceptability of *RestoSmart* in aiding the decision making process for post-endodontic restoration with high satisfaction in terms of its helpfulness, user-friendliness and potential usage in the future. Having demonstrated the usefulness of this interactive tool through questionnaires, we propose to expand our work by addressing its usability issues, providing justifications and alternatives for the recommendations provided, and including references to make *RestoSmart* a more evidence-based tool. Educators are also encouraged to implement innovative digital tools in order to create an interactive learning environment and improve student learning, but its performance must be evaluated.[29] This is because research has shown that technology is becoming an integral part of institutes of higher education for learning and communication purposes with web-based learning added to the existing teaching curriculum.[30]

Additionally, *RestoSmart* is scientifically designed to incorporate universally accepted treatment protocols and can be easily incorporated in each setting that uses English as a main language of communication.

Declaration of competing interest

There is no conflict of interests in this research.

Acknowledgements

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