Received: 21 October 2022 | Revised: 24 January 2023 | Accepted: 11 March 2023

DOI: 10.1111/eje.12907

ORIGINAL ARTICLE

WILEY

Aligning orthodontic education: Investigating the use of a digital app to improve the performance in managing orthodontic problems

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Abstract

Introduction: General dentists are qualified to manage orthodontic emergencies within their scope of practice. This may involve advice, hands-on intervention or referral to a specialist orthodontist. This study aimed to assess the effect of an orthodontic app on dental undergraduates' ability to manage common orthodontic issues. In addition, this study aimed to determine the confidence of dental students in finding information related to orthodontic emergencies (CFI) as well as their confidence in managing orthodontic emergencies (CMOE).

Materials and Methods: Students were randomised into one-of-three groups, an app group, an internet group and a closed-book, exam-style group. All participants self-reported their CFI and CMOE. Following this, all participants were asked to complete a multiple-choice question (MCQ) paper based on clinical orthodontic scenarios. In addition, the app group were instructed to complete an app usability questionnaire (MAUQ).

Results: Approximately, 91.40% of students ($n=84$) had not received clinical training in managing orthodontic emergencies, and 97.85% ($n=91$) had not managed an orthodontic emergency clinically within the last 6 months of their training. The mean score for CFI was 0.10 out of 1.0 (SD 0.11) and CMOE was 0.28 out of 1.0 (SD 0.23). Statistically significant better MCQ scores were found in the app group, and no statistically significant difference was found between the internet and exam-style group.

Conclusions: This study is the first to consider the use of an orthodontic app to aid in the management of orthodontic issues. It has practical implications for how mobile apps can aid in learning and can be incorporated into the wider dental field.

KEYWORDS
education, orthodontic app, orthodontic emergencies, orthodontics

1 | INTRODUCTION

In the UK, the General Dental Council (GDC) describe a series of learning outcomes that they expect newly qualified dentists to demonstrate prior to registration. This is outlined in the document 'Preparing for Practice'.[1] This list outlines the competencies required in several areas of orthodontics, including the ability to undertake limited orthodontic emergency procedures, for example breakage of a fixed appliance, headgear injuries, ingestion of an orthodontic bracket, etc.[1] The Association of Dental Education in Europe (ADEE) have a similar stance.[2] Management of an orthodontic emergency procedure necessitates forming the correct diagnosis and providing an effective management strategy. Depending on the scope of the practitioner, this may include hands-on intervention or alternatively, a referral to a specialist orthodontist.

Previous studies investigating the confidence of practitioners in their management of orthodontic emergencies have varying findings. Fleming et al.[3] found the self-reported confidence of general dental practitioners (GDPs) in managing orthodontic emergencies to be low, with a high level of self-perceived incompetence. However more recently, Popat et al.[4] found that GDPs felt confident when managing common orthodontic emergencies, despite subjects reporting limited exposure to this treatment in primary care.

Studies investigating dental students' exposure and confidence in orthodontic emergencies have also varied in their findings. Patel et al.[5] found that 60% of newly qualified dentists were not confident in managing an orthodontic patient, with this view also supported by their supervisor. Supervisors were also of the opinion that undergraduate orthodontic training was inadequate. Furthermore, in a multi-centre study of two universities, Honey et al.[6] found that students recognised orthodontic emergencies as one of their least confident procedures compared to other dental procedures. Conversely, in a qualitative study, Popat et al.[4] found that two-thirds of dental students reflected confidently towards managing orthodontic emergencies in a training environment. This finding was also supported by research from Jones et al., who found that 69% of students were confident in managing orthodontic emergencies and were also exposed to a relatively high number of orthodontic emergencies per academic year (6.3 patients per student). It is worth noting, however, that the findings from this study still suggest almost a third of students were not confident in independently managing orthodontic emergencies.[7]

It is common for apps to be used by healthcare professionals as an adjunct to their overall management strategy.[8,9] A rudimentary orthodontic mobile app was developed and deployed for this study. The contents featured guidelines, advice and knowledge available from the British Orthodontic Society as well as from other national- and international-independent professional bodies.[10] The app was designed to be an interactive evidence-based tool to assist clinicians in accessing current and accurate information on traumatic dental injuries, orthodontic emergencies and other orthodontic advice and guidance (Figure 1). Validation of the app content was carried out by multiple members of clinical staff by assessing usability. Usability questionnaires are tools used to evaluate the user-friendliness of a product or system. They typically consist of a set of questions or tasks that are designed to assess different aspects of usability, such as learnability, efficiency, memorability, errors and satisfaction.

It was proposed that the development and deployment of an orthodontic app would result in improvement in decision-making and management processes at an undergraduate level, improving confidence and therefore resulting in an improvement in outcomes for unfortunate patients.[1,2]

1.1 | Aims and objectives

The primary aim of this study was to investigate the effect of using a digital app on undergraduate dental students' performance in a multiple-choice question (MCQ) paper on managing common orthodontic emergencies.

The study also aimed to determine the self-reported confidence of final-year undergraduate dental students in finding information related to and managing orthodontic emergencies.

This study also intended to assess the usability of an orthodontic app designed to facilitate the delivery of guidance in managing traumatic dental injuries and orthodontic emergencies, with the goal of validating the use of apps within dental education.

2 | MATERIALS AND METHODS

2.1 | Ethics statement

Ethical approval for this study was granted by the King's College London Research Ethics Committee (Reference MRSU-21/22-28 333).

2.2 | Sample

The participants of the study were final-year undergraduate dental students studying at King's College University. As part of the undergraduate program, students undergo academic orthodontic teaching. Through clinical training, it is expected that students are exposed to orthodontic clinical emergencies in an emergency clinic.

The inclusion criteria included any final-year dental student present at the undergraduate clinic during the 2-week study window. The exclusion criteria included students with any further qualifications in orthodontics; including orthodontic therapy training, postgraduate qualifications in orthodontics or a previous orthodontic role, for example orthodontic nurse.

The participants were recruited via convenience sampling. Informed consent was gained from each participant and a written information sheet was provided detailing the extent of the investigation. A minimum of 30 students per group was set. The sample size was chosen with the consideration that there are a maximum

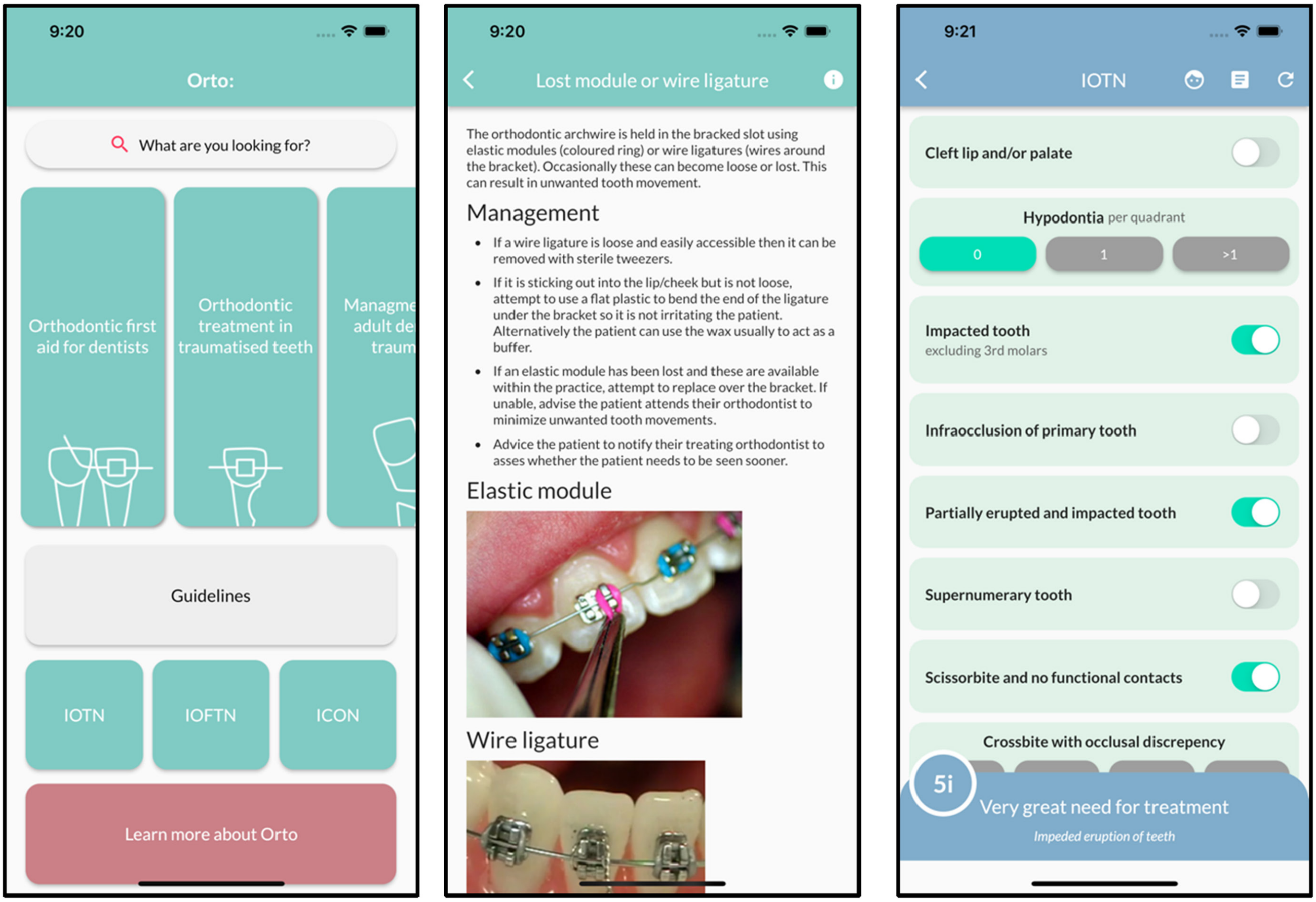

FIGURE 1 Screenshots of the orthodontic app used in this study.

number of potential recruitable participants (i.e. total number of final-year undergraduates).

2.3 | Methodology

A questionnaire was developed and divided into two separate sections. The first section involved the collection of basic information including gender, previous qualifications in orthodontics, previous undergraduate clinical training in orthodontic emergencies and the number of orthodontic emergencies managed in the previous 6 months. This was followed by two visual analogue scales (VAS) for participants to self-report their confidence in managing orthodontic emergencies (CMOE) and confidence in finding information related to orthodontic emergencies (CFI).[11] Both VAS measured 140 mm and scores were subsequently scaled to a value between 0 and 1, where 0 was not confident and 1 was confident.

The second section presented 24 orthodontic scenarios in the form of MCQs. The scenarios were based and adapted on data from previous studies that also investigated the presentation and management of orthodontic emergencies (Figure 2).[4,7,12] Prior to dissemination, the questionnaire was distributed to five different clinical members of staff (a professor in orthodontics, an orthodontic consultant, an orthodontic registrar, a dental core trainee and a general dental practitioner) in order to gauge the validity of the questions. Feedback was provided individually by these members of staff and further minor modifications were made accordingly.

All students present during the 2-week study window were invited to take part in the study. Enrolment was carried out in undergraduate teaching clinics by a single dental nurse (AM), independent of the research. Students were made aware that the MCQ paper was formative in nature and would not count towards their final grade.

Randomisation was completed by shuffling 115 brown envelopes containing the group allocation and participant instructions. One hundred and fifteen was the total number of students expected to be present during this study window. The brown envelopes were distributed by the independent nurse (AM) as each subject was enrolled. The allocation was concealed to the nurse by virtue of sealed envelopes. Within the instructions, Group A (app group) were advised to download and make use of the orthodontic mobile application to complete the MCQ paper; Group B (internet group) were allowed to use any internet-enabled device to complete the MCQ paper and Group C (exam-style group) were advised to undertake the MCQ paper in exam-style with no additional aids. In addition, subjects in the app group were instructed to complete a mHealth app usability questionnaire (MAUQ) following the completion of the MCQ paper.

A patient with a fixed orthodontic appliance attends for an emergency appointment. Part of the appliance has broken and the remainder has deeply lodged into the palatal soft tissues. What is the likely treatment that will need to be carried out?

1. Nothing, the broken appliance can be left in-situ
2. Removal without local anaesthetic
3. Removal under local anaesthetic
4. Removal under general anaesthetic

The mother of a patient calls to speak to you. The patient wears headgear and part of the appliance has broken and injured the patients eye. What advice do you provide to the patient?

1. Immediately attend the emergency dental clinic
2. Immediately attend the orthodontic clinic
3. Immediately attend A&E
4. Do nothing

A patient has swallowed an orthodontic bracket (<1cm). What advice do you give them?

1. The item is likely to pass in their stool. Ask the patient to monitor their stool for 6 days
2. Refer the patient to a local hospital. It is likely that an abdominal x-ray will be taken.
3. Refer the patient to a local hospital. It is unlikely that an abdominal x-ray will be taken.
4. Refer the patient to a local hospital. It is likely that a chest x-ray will be taken.

FIGURE 2 Examples of questions used in the MCQ exam.

The MAUQ was developed by the University of Pittsburgh and is a validated and reliable tool used to evaluate the usability of health-care apps for medical professionals.[13] It is made up of 18 items for which respondents provide a score from 1 to 7, where 1 is disagree and 7 is agree. The MAUQ can then be used to determine scores for three subscales, 'Ease of use and satisfaction', 'Interface and satisfaction' and 'Usefulness'.

Following completion, the subjects in all three groups were instructed to seal their envelope and these were collected by the same nurse (AM) before returning to a single investigator (JW) for data entry into a Microsoft Excel spreadsheet. The study was continued until a minimum of 30 participants per group was reached.

2.4 | Statistical analysis

The data were analysed by a single researcher (MS). The researcher was blinded to the interventions between the groups. The data were analysed using Stata 17 MP.[14]

For all hypothesis tests, statistical significance was set at $\alpha = 0.05$.

Descriptive statistics were used to provide information on the sample. A formal analysis was conducted on both the VAS scores from the first section of the questionnaire. The relationship between the two scores was determined using a binned scatter plot against a conditional expectation function obtained by ordinary linear regression. A binned scatter plot is a non-parametric plotting technique where the independent variable is divided into equally sized bins and the mean of the dependent variable is calculated for each bin; an ordinary least squares regression line can then be fitted to these points. In this study, the independent variable was CFI, and 20 bins were used.

In addition, the effect of the intervention group and gender on the VAS score was analysed using a general linear model with a gamma distribution as VAS data were right-skewed with non-normal distribution. Šidák's multiple comparisons of means was used for the post-estimation analysis.

The effect of the intervention group on the MCQ score was analysed using ordinary linear regression in conjunction with Šidák's multiple comparisons of means for post-estimation analysis.

Finally, an analysis was conducted on the results obtained from the MAUQ in order to evaluate the usability of the orthodontic app. Data were also interpreted and used to provide recommendations on methods to improve end-user experience in future mobile apps used for orthodontic education.

3 | RESULTS

3.1 | Sample

A total of 93 students participated in the study with a distribution of 31 in Group A, 30 in Group B and 32 in Group C. The gender of the respondents was 59.14% female ($n = 55$) and 40.86% male ($n = 38$). Eighty-four subjects (91.40%) had not received clinical training in managing orthodontic emergencies and 91 (97.85%) had not managed an orthodontic emergency within the last 6 months of their training. Only two respondents had managed one orthodontic emergency in the last 6 months (2.15%).

3.2 | Visual analogue scale

The mean VAS score for self-reported confidence in finding information related to an orthodontic emergency (CFI) was 0.10 out of 1 (SD 0.11). The mean VAS score for self-reported confidence in managing an orthodontic emergency (CMOE) was 0.28 out of 1 (SD 0.23).

The Pearson correlation coefficient between CFI and CMOE was $r=.37$, $p=.001$ (95% CI 0.17–0.58). The wide confidence interval reflects the scatter in the data as seen in the scatter plot. The regression line indicates an increase in CMOE with an increase in CFI (Figure 3).

There was no statistically significant effect of either intervention group or gender for CFI or CMOE and the results are summarised in Table 1 (CFI) and Table 2 (CMOE) in terms of margins.

3.3 | Multiple-choice question paper

Summary statistics for the MCQ scores are given in Table 3. The analysis of the effect of the intervention group on the MCQ score is summarised in Table 4. There was no statistically significant difference in the MCQ scores between the internet group and the exam-style group, however, there is a statistically significant improvement in MCQ scores in the app group.

3.4 | mHealth app usability questionnaire (MAUQ)

A total of 25 respondents out of 31 group A completed the MAUQ after using the orthodontic app (response rate 80.65%). It was unclear why the remaining six subjects chose not to complete this section. Table 5 provides the scores for each individual item within the MAUQ and the total score. Most items within the MAUQ scored highly for the orthodontic app.

The MAUQ can be further organised into three previously validated subscales: 'ease of use and satisfaction', 'interface and satisfaction' and 'usefulness' (Table 6). There was no statistically significant difference between the mean values of the subscales (Table 7).

4 | DISCUSSION

The primary purpose of this study was to investigate the effect of using a digital app on undergraduate dental students' performance in a MCQ paper on managing common orthodontic problems. This study found that there was a statistically significant improvement in a student's performance in the MCQ paper compared to locating information found on the internet or answering in exam style, without additional aid. This suggests that there is practical merit in delivering information, guidance and advice to health professionals through mobile applications.

Previous research has demonstrated that a proportion of dentists felt they had insufficient support in practising evidence-based dentistry (EBD) due to the lack of evidence-based information accessible at the point of care, such as important statistics and clinical guidelines.[15,16] Another key finding from this study was the lack of statistical difference between the internet group and the exam-style group in the MCQ paper. One would expect that the group who had access to the internet would perform better than those completing the MCQ paper in exam style, however, this was not the case. This finding supports the aforementioned research, and the present results could be attributed to the internet group having difficulty locating accurate guidance or professional information online.

In the past three decades, with the exponential growth in electronic resources, the use of online evidence sources has become essential for dental practitioners to deliver EBD. A secondary aim of this study was to determine the self-reported confidence of final-year undergraduate dental students in finding information related to orthodontic emergencies (CFI). This study revealed that final-year undergraduate dental students did not feel confident in this variable. In addition, the subsequent analysis found there to be a statistically significant correlation between CFI and confidence in managing an orthodontic emergency (CMOE), that is as the confidence in finding

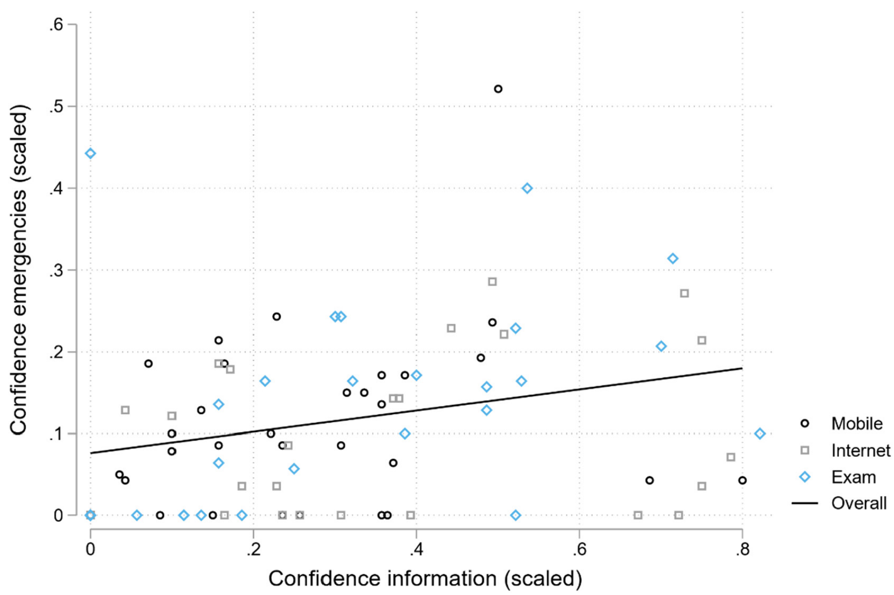

FIGURE 3 Binned scatter plot demonstrating the relationship between VAS scores for CFI and CMOE. The regression line for all groups indicates an increase in self-reported confidence in dealing with emergencies as self-reported confidence in finding information increases.

TABLE 1 Summary of the GLM analysis for self-reported confidence in finding information related to orthodontic emergencies (CFI).

CFI	Coefficient	$p > \|z\|$	95% conf. interval	
Group				
App group	0.000 (base)			
Internet group	3.625	.250	−2.558	9.808
Exam-style group	0.232	.923	−4.458	4.923
Gender				
Female	0.000 (base)			
Male	−0.020	.993	−4.383	4.343
Constant	8.957	.000	5.152	12.761

Abbreviation: GLM, general linear model.

TABLE 2 Summary of the GLM analysis for self-reported confidence in managing orthodontic emergencies (CMOE).

CFI	Coefficient	$p > \|z\|$	95% conf. interval	
Group				
App group	0.000 (base)			
Internet group	−0.326	.641	−1.693	1.042
Exam-style group	0.141	.851	−1.329	1.611
Gender				
Female	0.000 (base)			
Male	0.479	.490	−0.880	1.839
Constant	3.467	.000	2.482	4.452

information increases, the confidence in managing an orthodontic emergency increases.

A fundamental skill required for managing any healthcare procedure is having the knowledge to aid in diagnosis and management. This study discovered that only two students had managed an orthodontic emergency in the past 6 months of their undergraduate training and very few students had received any clinical training in managing orthodontic emergencies. It is unfair to expect a healthcare professional to be well-informed and competent in a clinical situation that they rarely face or may not have encountered before.

In non-orthodontic dental emergencies, many of the core skills can be learnt under direct senior supervision at the undergraduate level, however, due to limited exposure to orthodontics during undergraduate training, the same is often not the case for orthodontic emergencies. Outside of a secondary care setting, orthodontic patients will likely present to general dental practices sporadically at inconvenient times, often if they are unable to be seen by their regular orthodontist. If general dentists are unable to appropriately manage the orthodontic emergency, this could be detrimental to the orthodontic treatment plan.

TABLE 3 Results for each group in multiple-choice question (MCQ) paper. Score out of 24.

	Group		
	App group	Internet group	Exam-style group
n	31	30	32
Mean MCQ score	19.48	16.23	15.06
SD	3.63	2.57	2.98

TABLE 4 Multiple comparisons of means for MCQ scores. Groups with the same letter are not statistically significantly different.

	Margin	SE	Groups
App group	19.484	0.652	
Internet group	16.233	0.469	A
Exam-style group	15.063	0.528	A

Decision-support systems have been advocated since the advent of the digital revolution. DSS contains a specialised body of knowledge in a digital form that allows non-specialists to obtain expert-level information.[17] A major challenge in designing a suitable DSS is to integrate this seamlessly into the busy and complex clinical workflow. As smartphone use is almost ubiquitous in the demographic of practising dentists, a digital app may be the most suitable means to provide and distribute advice and guidance to dentists at the point of care.

The final aim of this study was to assess the usability of the orthodontic app used in this study within the undergraduate setting. Overall, the app demonstrated high usability scores when using the mHealth App Usability Questionnaire. This indicates that the respondents from this study were satisfied with the content and functionality of the app. Although not significant, it is worthwhile noting the comparatively lower score for the item:

> the app adequately acknowledged and provided information to let me know my progress.

(mean 5.04 SD 1.21). One area for future development could involve allowing the user to monitor their learning and exposure or potentially 'favourite'/'star' specific guidelines that the user accesses more often.

The orthodontic app used in this study was developed to enhance orthodontic knowledge and provide a quick and accessible reference guide for common orthodontic problems. It could be argued that theoretical knowledge may not be translated into effective clinical management. However, previous research has demonstrated that exposure to theoretical scenarios through continuous education and case discussions can help to enhance competence and confidence.[18]

This study has demonstrated the problems of using the internet to locate accurate and reliable guidance on orthodontic emergencies.

TABLE 5 Results for mHealth app usability questionnaire (MAUQ). n.b. score of 1 is disagree and 7 is agree.[13]

Subscale	MAUQ Item	Mean	SD
Ease of use	The app was easy to use	5.68	1.31
	It was easy for me to learn to use the app	5.60	1.35
	The navigation was consistent when moving between screens	5.84	1.07
	The interface of the app allowed me to use all the functions (such as entering information, responding to reminders and viewing information) offered by the app	5.56	1.16
	Whenever I made a mistake using the app, I could recover easily and quickly	5.48	1.48
Interface and satisfaction	I like the interface of the app	5.52	1.36
	The information in the app was well organised, so I could easily find the information I needed	5.44	0.92
	The app adequately acknowledged and provided information to let me know my progress	5.04	1.21
	I feel comfortable using this app in social settings	5.32	0.99
	The amount of time involved in using this app has been fitting for me	5.92	0.81
	I would use this app again	5.76	0.88
	Overall, I am satisfied with this app	5.84	1.14
Usefulness	The app would be useful for my healthcare practice	5.84	1.07
	The app improved my access to delivering healthcare services	5.92	0.95
	The app helped me manage my patients' health effectively	5.72	1.28
	This app has all the functions and capabilities I expected it to have	5.80	0.96
	I could use the app even when the Internet connection was poor or not available	5.76	1.16
	This mHealth app provides an acceptable way to deliver healthcare services, such as accessing educational materials, tracking my own activities and performing self-assessment	5.76	1.13

TABLE 6 Scores for the subscales within the MAUQ.

Scale	Mean	SD
Ease of use	5.63	0.92
Interface and satisfaction	5.55	0.84
Usefulness	5.80	0.87

It has also demonstrated the benefits of using an app to deliver information. Future mobile app developments will need to have a rigorous review process to ensure the evidence provided is correct and readable. In addition, there is a need for the entire profession to collectively initiate efforts to pool guidelines and knowledge so it is freely available and easily accessible to all.

4.1 | Limitations

Although the study was conducted rigorously some limitations need to be acknowledged. This study was carried out in a single context of final-year undergraduate dental students, hence the

TABLE 7 Multiple comparisons of means for MAUQ subscale scores. Groups with the same letter are not statistically significantly different.

	Margin	SE	Groups
Ease of use	5.632	0.175	A
Interface and satisfaction	5.549	0.175	A
Usefulness	5.800	0.175	A

results cannot be generalisable to the general professional dental population.

One could therefore argue that the outcome from the MCQ was inevitable due to the comprehensive nature of the content of the app. However, the results from the MCQ (mean = 19.5/24) suggest that the app and structure of content were in fact not the perfect means to disseminate guidance. This is also reflected in the less-than-perfect MAUQ scores, and further testing of new iterations of the app will need to be conducted to ensure app usability and validity. Further studies would also benefit from collecting qualitative feedback.

In addition, the duration in which data were collected may have affected the results. Although care was taken to prevent such issues from arising, there is a chance that participants in the later stages of the 2-week study window may have become aware of the content of the MCQ paper or been exposed to the app by their peers, and as a result, may have affected their performance in the MCQ paper.

5 | CONCLUSION

This study demonstrated that final-year undergraduate dental students reported a low level of confidence in managing orthodontic emergencies and a low level of confidence in finding information to aid in managing an orthodontic emergency. It is apparent that exposure to orthodontic emergencies and clinical teaching in this field at an undergraduate level is infrequent. The results from the MCQ paper used in this study demonstrate that there is both a need for and benefit of providing clinical advice, guidance and information through mobile applications. Further studies investigating the usability of apps for dental professionals are required.

ACKNOWLEDGEMENTS

The authors would like to acknowledge Professor Martyn Sherriff for his guidance and support with the statistical analyses. The authors would also like to thank Mohamud Ayaam for her assistance in the distribution of the question papers. The authors would also like to thank those involved in the development of the content for the mobile application including Stuart Worthington and Hannah Hook. In addition, the authors would like to acknowledge the British Orthodontic Society and International Association of Dental Traumatology for allowing the use of their guidelines within the mobile application.

FUNDING INFORMATION

The author(s) received no financial support for the research, authorship, and/or publication of this article.

CONFLICT OF INTEREST STATEMENT

The author(s) declare no potential conflict of interest with respect to the research, authorship, and/or publication of this article.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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How to cite this article: Woolley J, Bister D, Sherriff M, Jeremiah H. Aligning orthodontic education: Investigating the use of a digital app to improve the performance in managing orthodontic problems. *Eur J Dent Educ*. 2023;00:1-9. doi:10.1111/eje.12907