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Educational Article

Effects of handpiece speed on the performance of undergraduate dental students in preclinical training

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الملخص

أهداف البحث: تعد قبضات تحضير الأسنان منخفضة السرعة عالية العزم شائعة الاستخدام في تدريب طلاب طب الأسنان بالمرحلة قبل السريرية، وبالرغم من ذلك، فإن القبضات التوربينية الهوائية عالية السرعة هي التي تستخدم بشكل شائع خلال الممارسة السريرية. وهذا التباين يخلق فجوة بين مهارات التدريب ما قبل المرحلة السريرية والسريرية. تهدف هذه الدراسة إلى مقارنة استخدام القبضات عالية السرعة والقبضات منخفضة السرعة من قبل طلاب طب الأسنان في المرحلة ما قبل السريرية.

طرق البحث: شارك في هذه الدراسة ٢١ طالبا من كلية طب الأسنان بجامعة طيبة. وقد طلب من كل طالب تحضير حفر من الصنف الأول باستخدام القبضة التوربينية الهوائية عالية السرعة، وحفر من الصنف الأول باستخدام القبضة الهوائية منخفضة السرعة عالية العزم، وتم تسجيل الزمن الذي تم فيه انجاز المهمة. بعد ذلك تم تقييم جودة الحفر باستخدام مقياس من ٦ نقاط (من ١ إلى ٦) وتم تحليل النتائج إحصائيا.

النتائج: لم يكن هناك أي فرق مهم في متوسط زمن تحضير الحفر بين القبضات منخفضة السرعة وعالية السرعة (٥٣٨.٢٩ ثانية و٤٨٣.٧٦ ثانية على التوالي). وأما بالنسبة لتقييم جودة الحفر فلم يكن هناك أي فرق في جودة الحفر المحضرة بالقبضات منخفضة السرعة وعالية السرعة، وكذلك لم يكن هناك أي فروق واضحة بالنسبة لخشونة السطح.

الاستنتاجات: إن نوعية القبضة المستخدمة لا تؤثر على قدرة تعلم طلبة المرحلة الجامعية لتحضير حفر الصنف الأول، حيث إننا لم نلاحظ أية فروق ذات دلالة إحصائية بين الحُفر المحضرة من قبل الطلبة باستخدام القبضات عالية السرعة والقبضات منخفضة السرعة.

الكلمات المفتاحية: إعداد تجويف الأسنان; تعليم طب الأسنان; سرعة قبضة تحضير الأسنان; طلاب طب الأسنان بالمرحلة الجامعية

Abstract

Objective: Low-speed high-torque handpieces are popular for the pre-clinical training of dental students. However, in clinical practice, high-speed air turbine handpieces are commonly used. This dissimilarity creates a gap between pre-clinical and clinical training skills. The current study sought to evaluate the effects of the use of high-speed and low-speed handpieces by dental students during their pre-clinical training.

Methods: Twenty-one undergraduate dental students at the College of Dentistry of Taibah University participated in this study. Each student was asked to prepare class I cavities using high-speed air turbine and low-speed/high-torque handpieces. The time required for cavity preparation was recorded by the authors. The prepared cavities were evaluated for quality and skill using a six-point scale. The data were statistically analysed with paired t and Mann–Whitney tests.

Results: There was no significant difference in cavity preparation time between the low-speed and high-speed handpieces (538.29 and 483.76 s, respectively). The evaluations of the cavities revealed no difference in the quality of preparations between the low- and high-speed handpieces. Additionally, no significant difference in the surface roughness of the preparations was observed.

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Conclusions: The type of handpiece did not influence the learning capabilities of the undergraduate dental students in the preparation of preparing class I cavities. This study did not observe any significant differences between the cavities that were prepared by our students using either high-speed or low-speed handpieces.

Keywords: Dental cavity preparation; Dental education; Handpiece speed; Undergraduate dental students

Introduction

There is a high level of demand for qualified dental clinicians and educators across the world. A number of factors, such as increases in the population, improved public awareness of dental care, and advancements in dental technologies and knowledge in dentistry, have further intensified the need for trained dental professionals. However, ensuring high quality dental education and training in practical skills for students is challenging.[1,2] Practicing manual skills and training improve the performances and spatial perceptions of learners. Manual skills and perceptual abilities are essential in clinical dentistry practice.[3] Preclinical operative dentistry modules contribute a large proportion of the credit/teaching hours that compose the dental curriculum.[4] A variety of lead-up activities have been developed to assist the early development of psychomotor skills for operative dentistry.[5] To equip students and enable them to operate efficiently and safely in the clinic, students are trained to foster practical skills in simulated educational settings.

The handpiece is a key instrument in dentistry that is used for a number of functions including the removal of caries, cavity preparation, tooth tissue grinding, and the finishing and polishing of restorations. The first air rotary handpiece was pioneered by Green in 1868,[6] and this handpiece was followed by electric handpiece technologies that commenced in 1873.[7] The modern air turbine handpieces were introduced by Borden within the last century (1957) and can attain very high speeds [up to 300,000 rpm]. High-speed dental air turbine handpieces fomented a revolution and significantly altered dental practice.[8] Air turbine handpieces attained popularity and are actively used in clinical dentistry. In North America, high-speed handpieces are used for the majority of clinical procedures involving fixed prosthodontics in pre-doctoral programs.[9] These handpieces are highly popular due to specific benefits, including low cost, low weight, ease of repair, rapid cutting of the tooth structure, and a reduced risk of pulpal damage.[10–12]

In the majority of Middle Eastern Universities, the traditional teaching approach for operative dentistry preclinical training relies primarily on the use of low-speed handpieces. However, in the clinical stage, the majority of dental procedures (e.g., cavity and crown preparation) are performed with high-speed air turbine handpieces. Therefore, undergraduate dental students receive very limited exposure to the use high-speed air turbine handpieces prior to clinical sessions. This situation leads to a gap between the preclinical and clinical stages. The current study sought to evaluate the effects of the use of high-speed and low-speed handpieces by dental students during preclinical training. Additionally, the effects of handpiece speed on the undergraduate students' abilities to learn operative procedures were examined.

Materials and Methods

This study was approved by the Research Ethics Committee of the College of Dentistry of Taibah University. An entire class of 21 students who were taking the "preclinical dentistry module" were informed about the study and all agreed to participate. All of the students were informed about the study design, their potential participation and the procedures for preparing conventional GV Black's cavities (class I). Each student was provided with a pair of artificial lower right first permanent molar teeth (KaVo EWL model teeth, KaVo Dental GmbH & Co.KG). All KaVo model teeth are synthesized using food-resistant materials [i.e., no chemical interactions with food ingredients], and their hardnesses match that of human dentine.[13] Natural dentin is a hard material with hardnesses that range from 0.4 to 0.9 GPa.[14,15] Therefore, the learners experienced proprioceptions that were very similar to those that would be experienced with natural teeth, and there are no safety issues involved in the use of synthetic teeth. To standardize the research, each student was provided with similar teeth and instruments and a comfortable stress-free working environment. Each student was asked to cut a class I cavity using a turbine hand-piece (POWERtorque MULTIflex LUX Turbin 646B KaVo Dental GmbH & Co.KG) with continuous water spray [Group A] and using a low-speed handpiece with high-torque (INTRAflex LUX 2Uniterteil 2320 LN KaVo Dental GmbH & Co.KG) [Group B]. The cavity outlines included all occlusal pits and fissures with gently flowing curves and distinct cavo-surface margins. Conservative GV Black class I cavities should meet the criteria listed in Table 1).[12]

All students were provided with a dental mirror, probe, and millimetre-graduated periodontal probe to measure the depth, width and marginal width of the cavity. All preparations were completed using tungsten carbide burs with head lengths of 1.8 mm and tip diameters of 0.8 mm (ISO standard No. 330: Hager & Meisinger GmbH-Germany).[12] Once the cavity preparations were completed, all teeth were collected, labelled with the study group and evaluated by the authors according to the predefined criteria (see Table 2). The data were analysed using the SPSS version 16 statistical software (SPSS Inc., Chicago, IL, USA) for Windows, and t-tests for paired samples and Mann–Whitney tests were applied.

Surface roughness measurement

The surface roughness analyses of the prepared class I cavities was performed using a previously described protocol.[16] Briefly, a noncontact surface profile-meter (Bruker® 3D optical system; type ContourGT-K0) was used to scan the surfaces. This surface profilometer has a built-in sample

Table 1: Parameters for the preparation of an ideal class I cavity.[12]

Parameter	Criteria
Outline form	All occlusal pits and fissures; flowing curves and distinct cavo-surface margins
Cavity depth	1.5–2 mm
Cavity width	1–1.5 mm
Divergence of mesial/distal walls	≤10°
Convergence of facial/lingual walls	minimal occlusal convergence
Cavo-surface angle	80–100°
Marginal ridge width	At least 2 mm
Pulpal floor	smooth and flat

Table 3: Mean preparation times (seconds) required for class I cavity preparation.

Study group	n	Mean	Std. deviation
Group A: High-speed handpieces	21	483.76	328.666
Group B: Low-speed handpieces	21	538.29	247.765

$t = 0.607$, $p < 0.05$.

stage that can be moved physically in X, Y, and Z planes for final sample adjustment. This profilometer is equipped with a camera (20× mounted lens, single objective adapter). The roughness profiles of the walls and floors of the prepared cavities were analysed using the Vertical Scanning Interferometry (VSI) technique; hence, no destruction of the sample surfaces occurred. All teeth were cut vertically to access the walls and cavity floor without any obstruction from the undercuts. The prepared samples were attached to the top of the sample stage, and the X and Y positions were adjusted to bring the sample under the lens. The Z-axis was then adjusted to move the object into focus. Once satisfactory focus was attained, Vision64™ operation and analysis software was used to obtain the surface roughness profiles.

This machine is proficient in the measurement of characteristics at a resolution of 1 μm and can be calibrated for vertical and horizontal resolutions. There is a range of parameters that can be calculated using the software that includes profile or line roughness (abbreviated as Rq, Rs) and surface area roughness (abbreviated as Sq, Sa). The line roughness (Rq, Ra) has frequently been used to express the surface roughness (SR parameter paper). However, the latest 3-D non-contact profilometers are capable of measuring area roughness parameters (Sq, Sa) that are more accurate and a parameter for roughness profilometry. The line and surface area parameters can be expressed with the following equations:

$$R_a = \frac{1}{l}\int_0^l |Z(x)|d_x$$

where *'l'* is the length of line, and

$$S_a = \frac{1}{A}\int_0^A |Z(x,y)|d_x d_y$$

where A is the area.

The collected data were analysed for the root mean squares of the surface roughness (S_q). Five measurements from each sample were obtained and averaged to acquire the final S_q values.

Results

Preparation time

The mean times required by the students to prepare the class I cavities were 538.29 s and 483.76 s with the low- and high-speed handpieces, respectively (Table 3). There was no significant difference in the means of the cavity preparation times between the low- and high-speed handpieces (p-value < 0.05).

Cavity evaluation

To evaluate the relationship between handpiece speed and cavity preparation quality, the two groups were compared in

Table 2: Evaluation criteria used to assess the prepared class I cavities.

Parameter	Evaluation score		
	1	0.5	0
Outline form	Proper	Moderate deviation	Unacceptable
Cavity depth	1.5–2 mm	<1.5 mm or 2–3 mm	<1 mm or >3 mm
Cavity width	1–1.5 mm	Moderate deviation 2–2.5 mm	Improper <1 mm or >3 mm
Marginal ridge index	1.5–2 mm	Moderate deviation 2.5–3 mm	Unacceptable >3 mm
Convergence or divergence	Proper	Parallel	Improper, very converge/diverge
Pulpal floor	Flat	Moderate deviation	Unacceptable

Cumulative score for each cavity

Score	Code	Level	Grade description
0–2.5	1	Unacceptable	Gross mistakes or great deviation from proper design
3–4.5	2	Acceptable	Moderate deviation from proper design
5–6	3	Proper cavity	No suggestions for improvement or there are very small deviation from proper design

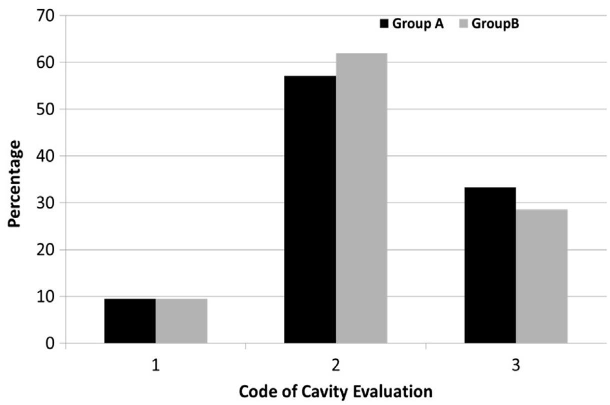

Figure 1: Comparison of the study groups in terms of the evaluations of class I cavities that were prepared by the students using high- (group A) and low-speed handpieces (group B); Code 1 [Unacceptable], Code 2 [Acceptable], Code 3 [Proper].

terms of variations using the criteria described in Table 2. Code 1 cases (i.e., unacceptable levels) were observed in 9.52% of the class I cavities in both groups (Figure 1). Regardless of the handpiece speed or type, more than 90% of the students were able to prepare acceptable or proper cavity formations. Acceptable levels were observed in 57.14% and 61.90% of the cavities in groups A and B, respectively. Proper cavity preparations were achieved 33.33% of the group A and 28.57% of the group B students. Statistical analysis revealed no significant difference in cavity preparation performance between the groups (p-value>0.05).

Surface roughness

Surface roughness profilometry was performed for the walls and floors of the prepared class I cavities. Representative (two-dimensional) images of the surface roughness profiles of the cavity walls and floors are shown in Figure 2. No significant difference ($p > 0.05$) was observed in the surface roughnesses of cavities that were prepared using the high- and low-speed handpieces (Table 4). The surface roughnesses of the cavity walls were 3.85 ± 1.55 μm and 3.16 ± 0.76 μm in the high- and low-speed handpiece groups, respectively. The surface roughness values for the cavity floors were greater than those of the walls in both groups. The high-speed handpieces (groups A) resulted in slightly rougher cavity floors (7.21 ± 2.69 μm) compared to the low-speed handpieces (4.60 ± 1.48 μm); however, this difference was not significant ($p > 0.05$).

Discussion

Dental handpieces and burs are among the mechanical devices that are most frequently used for ablating dental hard tissues. Although high-speed air turbine handpieces are dependable devices for cavity preparation in clinical practice, low-speed handpieces are still commonly used to prepare cavities in artificial teeth during preclinical training.[4] Safety

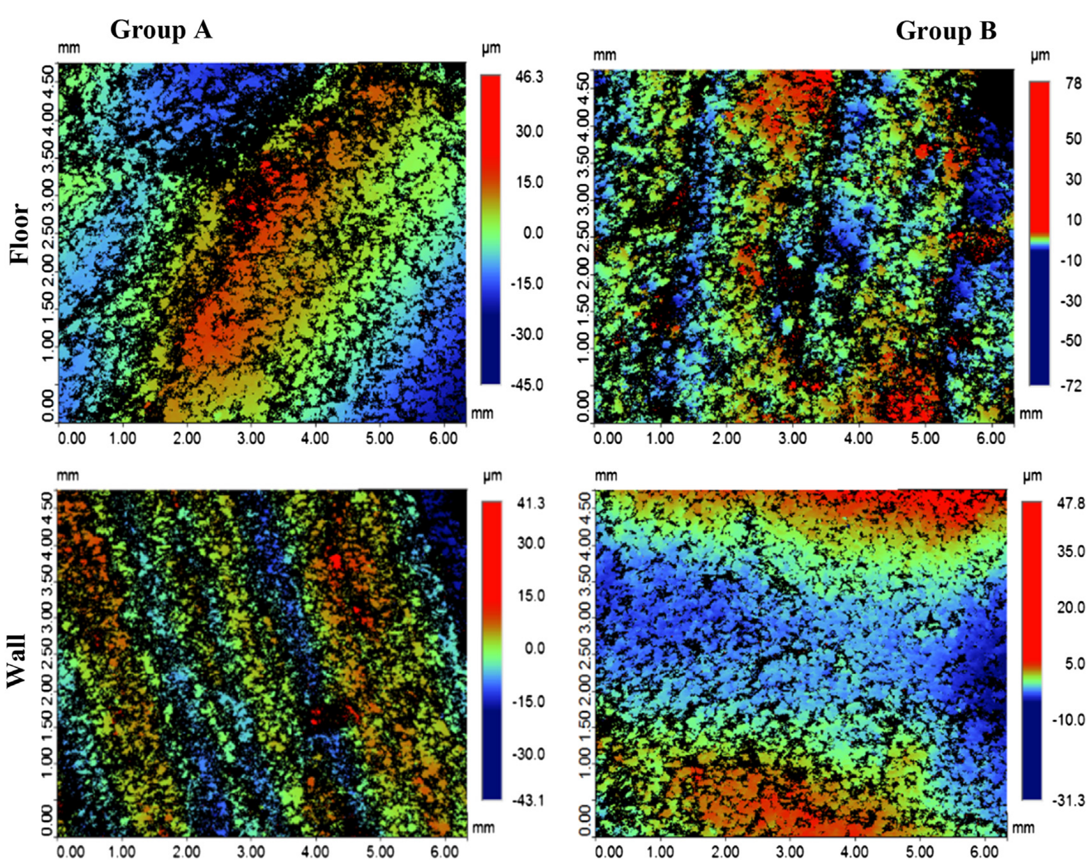

Figure 2: Representative surface roughness profilometries of cavity walls and floors that were prepared by undergraduate students using high- (group A) and low-speed (group B) handpieces.

Table 4: Area surface roughnesses of the prepared class I cavity walls and floors.

High-speed (Group A)		Low-speed (Group B)	
Wall	Floor	Wall	Floor
3.85 ± 1.55 μm	7.21 ± 2.69 μm	3.16 ± 0.76 μm	4.60 ± 1.48 μm

$p > 0.05$.

and conservative preparation have been offered as the justifications for the use of low-speed handpieces by dental students during preclinical training. Over the years, many dental educators have monitored distinguished dental trainees and observed them to experience difficulty performing clinical procedures at the commencement of training.[17] In the present study, we attempted to evaluate the effects of the use of high- and low-speed handpieces on the performances of dental students during preclinical training in an operative dentistry course. We evaluated the time required for cavity preparation and the quality of the design and surface roughness of prepared cavities in artificial teeth. The results did not reveal any differences in the performances of the students in terms of time consumed, quality of cavity design, or delicate features, such as surface roughness. A possible reason for the lack of difference in the preparation time between the low- and high-speed handpieces is that the trainees were novices, and it is possible that, with training, they will prepare cavities in shorter times with high-speed handpieces.

According to Gulliani et al.,[17] manual capability is not solely related to practical and mechanical essence but is also effectively associated with the mental abilities of planning, analysis and verification. The perceptual ability of dental students was found to be a very important factor the study of Gulliani et al., and the Perceptual Ability Test (PAT) scores of dental students have been found to be valid cognitive determinants of the spatial abilities of dental school applicants.[18–21]

Low-speed air turbine handpieces resemble electric motors; the main disadvantages are the large size and high weight compared to air turbine high-speed handpieces.[22] The large size of the handpiece head might hinder the access and visibility of the operator. Additionally, the large size and high weight might lead to ergonomic problems, particularly for certain operators.[23] The trauma to the tooth structure caused by air turbine high-speed handpieces is minimal when they are used correctly.[23] A logical cutting system includes rotary instruments that are defined by satisfactory power/cutting effectiveness and acceptable noise level and aerosol production. Furthermore, cost effectiveness, corrosion resistance following frequent sterilization cycles and an inbuilt light source are also important.[10] High-speed air turbine handpieces fulfil these all of these criteria better than low-speed handpieces.[10]

The main purpose of preclinical teaching and learning is to ensure a smooth transition of the dental students to the clinical stage. When students use low-speed handpiece in preclinical training, they build a mental image of the tactile senses and spatial abilities that is related to this type of handpiece. Therefore, when they initiate their clinical training, their use of high-speed handpieces is based on this mental image, which causes problems and iatrogenic accidents. This study has some limitations; e.g., clinical conditions could not be simulated because the students prepared artificial teeth in a phantom laboratory. Clinical dental work is significantly more difficult than preclinical work due to factors that include variations in mouth opening, excessive salivation, large tongues and patient fear. These factor are absent in preclinical training, which renders clinical work challenging for trainees. In such circumstances, the abilities of trainees to efficiently use high-speed handpieces will be greatly beneficial.

Conclusions

Within the limitations of this study, it can be concluded that the type of handpiece does not influence the learning capabilities of undergraduate dental students for the preparation of class I cavities. We did not observe any significant differences between the cavities that were prepared by our students using the high- and low-speed handpieces. The use of high-speed handpieces can reinforce undergraduate students' confidence and ensure the smooth translation of their operative dental cognitive and psychomotor skills from the phantom laboratory to clinical practice. We strongly recommended the use of high-speed handpieces in operative dentistry preclinical training courses.

Conflicts of interest

The authors have no conflict of interest to declare.

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