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Original Article

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Effectiveness of Educational Intervention with non-wax and Virtual Typodont Methods in Practical Orthodontic course of Dental Students, Shahid Beheshti University of Medical Sciences

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Objectives Considering the educational value of non-wax and virtual typodonts, in this study, the results of the evaluation were compared to quantify each of the indicators in the evaluation of knowledge, attitude, and performance.

Methods All tenth-semester dental students were divided into 2 equal groups of 25 and were trained by two typodontists. A standard questionnaire with a Cronbach α of .830 was used to evaluate their knowledge and attitude, which was prepared based on a 7-point Likert scale. To analyze the data, the paired t test, independent t test, and analysis of covariance (ANOVA) were used with SPSS version 21. The significance level was set as 0.05.

Results In each of the 2 educational methods, a significant increase in the overall score of the questionnaire completed by the students was observed after the educational intervention ($P < 0.001$). Among the 17 questions related to students, only 1 question in the non-wax typodont group and 4 in the virtual typodont group did not show a significant effect of the intervention ($P > 0.05$).

Conclusion Both typodonts had remarkable educational advantages and accounted for a large share of the points in the questionnaires. In cases where physical sense was important in education, non-wax typodont and in cases where spatial understanding of biomechanics was necessary in tooth movement, virtual typodont was superior.

Keywords Orthodontics; Teeth; Virtual; Education; Effectiveness; Dental student; Educational intervention

Introduction

All dental scientific texts consider this field a combination of science and art. [1] In teaching dentistry, especially orthodontics, teaching and transferring skills from tutor to student is associated with difficulties such as physical limitations in performing the procedure or a large variety of abnormalities. One of the essential components of orthodontic treatment is a treatment plan specific to each patient that must be well implemented. The treatment plan begins with a proper diagnosis and continues with classifying identified problems in order of importance.

Currently, all abnormalities are not taught in practical courses in orthodontics. The reason is that orthodontics requires long-term follow-up of patients to see treatment results. Therefore, students cannot master orthodontics, and this causes problems such as not having the self-confidence to perform orthodontic treatments and difficulty in diagnosing and treating and referring patients promptly.

Naturally, for this group, teaching the basic concepts of orthodontic biomechanics with practical and concrete methods by providing a three-dimensional view of teeth, jaws, forces, center of resistance, center of rotation and state of forces and torque is very practical and usable.

In the course of general dentistry, students spend a limited time in the orthodontic department, and the number of orthodontic patients requiring removable treatment is limited to 1 or 2 patients. Therefore, to comply with educational justice, it is necessary to include educational content related to all types of abnormalities in non-wax typodont (without placing in hot water) or virtual typodont for practical training of biomechanics and their clinical considerations.

In a research, the authors used orthodontic screws for anchorage control and demonstration of the applied biomechanics by changing the direction and amount of force, using plaster models (plaster typodont) filled with wax, which allows the teeth inside the wax to move. [2]

In 2014, Lee et al, tried to provide a new method in creating a three-dimensional imagination of the teeth and roots position with a single CBCT and without the need for repeated radiations, using a wax typodont and placing the extracted natural teeth in the wax. [3]

In a study, root control during the mesiodistal movement of the tooth roots with conventional brackets and self-ligating brackets using wax typodont were evaluated by placing them in hot water. This evaluation conducted for space closure of the extracted teeth. The authors acknowledged the limitations of the wax typodont and emphasized that the tissue reaction of the bone is inconsistent with the wax. [4]

Kim et al. (2017) used wax typodont to evaluate the movement of 6 anterior teeth. They heated the metal teeth using electrical induction, and facilitated their movement in the wax. The finding regarding the control of extrusion and Linguoversion of the anterior teeth is appreciable. Still, the

wax was separated from the metal tooth with a slight movement of the teeth. [5] In a study using simulation methods, tooth preparation techniques were improved for dentistry students before entering the clinic. [6]
the accuracy and repeatability of linear indicators in physical typodonts, such as resin, plaster, and 3D printed models, was compared with digital 3D models by a 3Shape R700TM laser scanner. Therefore, virtual models are as accurate as physical ones and can replace them. [7] Other researchers compared plaster models with Cone Beam computed tomography (CT) images and images obtained from laser scanning of the models and concluded that the measurements were within the clinically acceptable range. [8]
Generally, visual inspection (VI) for students' wax-ups is subjective and causes differences in examiners' evaluations. Digital techniques can be used in "self-evaluation" and corrections of individual techniques. [9] Researchers have recommended their method based on digital analysis to the facilities equipped with intraoral scanners. [9]
In another study in South Korea, a special patient-customized typodont was used. While the preparation tools irreversibly remove tooth structure, the use of this special typodont as a teaching tool can be very effective in transferring the practical knowledge of pre-clinic students to the clinic. [10]
In the Journal of Dental Education (an official publication of the American Dental Education Association), an article entitled "use of digital technology to improve objective and reliable assessment in dental students' simulation laboratories" has been published. During the traditional (visual) evaluation, none of the examiners had an excellent Cronbach coefficient, while this coefficient was excellent using PrepCheck software. It should be noted that more researches are necessary to validate PrepCheck and clarify its limitations. [11]

Methods and Materials

This study was approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences (code: IR.SBMU.SME.REC.1400.052). In this interventional study, all tenth-semester dental students of Shahid Beheshti University of Medical Sciences were divided into 2 equal groups of 25 to compare the effectiveness of 2 types of typodont training (non-wax and virtual) in performing orthodontics. After obtaining informed consent, the students were included through a full sampling method and were informed about the purpose of the study. The students' satisfaction level was measured using a standard questionnaire at the end of the study. In the intervention group, 44% of the investigated samples were male, and 56% were female.
Cronbach α was used to check the scientific reliability of the tool. The questionnaire was administered to the students, the information was entered into SPSS version 21 (SPSS Inc, Chicago, Ill, USA), and the correlation coefficient was used to confirm the scientific reliability of the research tool. The Cronbach α coefficient of this questionnaire was found to be 0.83. The questionnaire had 17 questions, and the reliability of each tool was examined separately.
This research investigated the effect of non-wax typodont (Figure 1) and virtual typodont (Figure 2) educational interventions in the practical orthodontic course. Dental students completed the form once before the educational intervention and once after it in the two groups (non-wax and virtual). The answers were entered into Excel software, and statistical tests were performed using SPSS version 21. An independent t test was used to compare the scores of the two groups before the educational intervention, and paired t test was used to compare the scores before and after the training in each group. An independent t test was used to compare the final grades between the two educational groups. The effect of the difference between the two groups in terms of scores before the intervention was controlled by analysis of covariance (ANOVA), and thus the comparison of the scores after the intervention between the two groups was not affected by the differences between the two groups before the intervention.

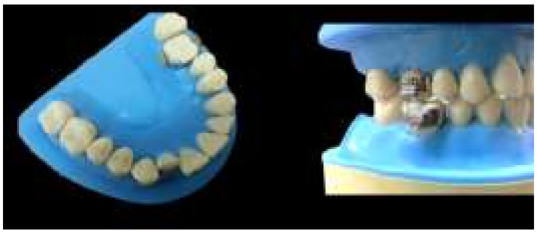

Figure 1: Non-wax typodont. The abnormalities include the anterior crossbite of the lateral tooth and the crossbite of the first molar.

Figure 2: Virtual typodont. The method for opening the middle screw of the device and activating the springs to remove the lateral teeth from the crossbite.

Results

In the anterior crossbite anomaly, Z-Spring activation and the amount of activation using non- wax typodont and displaying it in a virtual 3D space had a significant effect for students ($P < 0.001$).
Teaching the performance and the purpose of using Z (Double running title is incorrect in this page and page70 Spring) in non- wax typodont and virtual typodont had a significant effect on students ($P < 0.001$). In the virtual space, the force distribution system, the distance from the center of resistance

to the applied force, the creation of the center of rotation following the application of force, and the torque caused by force from the spring were explained, and it was educationally attractive for the students.

C-Clasp Adjustment using non-wax typodont had a significant effect on students (p<0.001). C-Clasp adjustments play a significant role in maintaining the device in the patient's mouth. Devices that do not have enough retention face problems in the patient's cooperation to use the device. This tutorial method makes the C-Clasp Adjustment very tangible. In virtual typodont, the effects of this training did not increase significantly for students (p=0.861). as the virtual name implies, this environment does not have the possibility of creating a feeling of changing the shape of the wire and a sense of touch. Therefore in the virtual training method; C-Clasp Adjustment was not attractive and concrete for students.

Labial bow adjustments using non-wax typodont was significantly effective (P < 0.001). Different tools, such as #139 pliers and 3 prong pliers, and their functions for the maximum adaptation of the labial bow as part of retainer and activating the side loops using 3-horned pliers and adjusting the bow part on the buccal surface of the incisors by using 3-horned pliers and #139 pliers, were evaluated. Not irritating the mucous membranes and lips are among the skills that should be taught at this stage through brief changes in the labial bow. In virtual typodont, the effects of this training did not increase significantly for students (P = 0.819). Explaining how to adapt the labial bow, its correct placement, force distribution after the activation of the loops, and the effects of the loops activation on the force and torque were possible to some extent, but as expected, the lack of AR and VR (Augmented Reality and Virtual Reality)
facilities in this system prevented effective communication between learners and different application of pliers and activation in these settings.

Teaching how to use cross-elastic (X-elastic) using non- wax typodont and virtual typodont had a significant educational effect on the students (P < 0.001).

Teaching the importance of using Jack Screw in space regaining and molar distalization in non- wax typodont and virtual typodont was attractive for students and significantly increases the educational effect (P < 0.001). Regarding using screws, non-wax typodont were attractive for students (P < 0.002). Opening the screw was challenging for the students, and with practice, this was transferred from the patient's mouth to the typodont exercise environment. The effects of this training for the students did not increase significantly in the virtual typodont (P = 0.642). How to open the screw and create enough space for tooth eruption, how to open the screw and levers to guide the screw axis, how to visualize the molar, and describe the function of the 3D space force components were well displayed in virtual typodont. The displacement of the teeth, along with slow growth and development of the premolar root in 3D space, was very influential in better understanding the space provision mechanism.

The outcomes of each round of screw loosening in non-wax typodont training did not have a significant effect for students (P = 0.335). Screw loosening following several rotations and 1 mm for every 4 rotations in the direction of the guide arrow was not attractive to students. Still, in virtual typodont, the effects of this training were significant and attractive (P < 0.001). With each round of opening, its effects on the displacement of teeth were observed. The amount of effect of each round of the screw opening was visible in the virtual environment.

In maxillary anteroposterior and mediolateral expansion orthodontic abnormalities using a 3D screw or Bertoni screw, the effects of training, the performance, the application, and the effect of each round of 3D screw opening in non-wax and virtual typodont were attractive to students and had a significant increase in educational effect (P < 0.001). positioning the teeth in class III malocclusion and correction of this situation after opening both parts of the 3D screw (lateral and anterior) result in a better understanding of the importance of the Bertoni screw function.

Teaching how to adjust the Adams clasp in non-wax typodont was attractive for students and showed a significant increase in training (P < 0.001). Due to the physical nature of the wax-free typodont, adjusting the Adams clasp is challenging to gain sufficient skill in retention of the appliance. Practice in adjusting the arrowheads and the higher parts of the clasp and its adaptation to the marginal ridges is a skill that minimizes clinical problems. Of course, the effects of this training for students did not show a significant increase in virtual typodont (P = 0.479). Setting up the Adams clasp in the virtual environment can be described in detail. The exact location of the bends in the clasp wire and the arrowheads' exact location under the free gingiva or the height of contour can be displayed in virtual space with high accuracy. However, as expected, the lack of AR and VR facilities in this system made the possibility of effective communication out of reach. The results are summarized in Table 1.

Discussion

In general, educational interventions in non-wax and virtual typodonts improved learning, knowledge, and skills and increased student satisfaction. Evaluating the performance of typodonts for learners with different degrees of clinical experience is usually limited to fixed devices and brackets. [5, 12] It is estimated that up to 40% of clinical procedures performed by general dentists in large Canadian cities may involve some form of orthodontic treatment. Students attach cemented bands, brackets, and archwires and install and adjust headgears on the simulation system. [13] In the design of this simulation system, special attention has been on fixed orthodontic systems. Adapting the wire and adjusting the bracket position on the tooth are essential skills in fixed orthodontic treatments. In the author's opinion, hitherto, insufficient budget allocation to Removable treatments, the lack of precision in practical training, and the lack of validation of learning the skills of adjusting orthodontic devices are the missing link in the practical training of Removable orthodontics that has been neglected.

Table 1. Summary of the Students' Questionnaire Results: Mean Values and SDs Before and After the Intervention in non-wax typodont and Virtual Training

	Typodont training method without wax							Virtual training methods							The comparison of scores after educational intervention between 2 groups (*P* value)
	Before training		After training		Changes before and after training		***P* value**	Before training		After training		Changes before and after training		***P* value**	
Question	Mean	SD	Mean	SD	Mean	SD		Mean	SD	Mean	SD	Mean	SD		
1	3.80	.707	5.60	.764	-1.80	0.96	<0.001	3.80	.707	5.60	.816	-1.80	1.19	<0.001	1
2	3.84	.850	5.72	.980	-1.88	1.33	<0.001	3.84	.746	5.92	.862	-2.08	1.12	<0.001	0.45
3	3.64	.638	5.64	.907	-2.00	1.15	<0.001	3.68	.852	5.96	.790	-2.28	1.10	<0.001	0.20
4	3.76	.779	5.56	.768	-1.80	1.26	<0.001	3.88	.833	3.92	.702	-0.04	1.10	.861	<0.001
5	3.76	.723	5.60	.707	-1.84	1.11	<0.001	3.84	.624	3.88	.726	-0.04	0.89	.819	<0.001
6	3.76	.779	5.00	1.000	-1.24	1.20	<0.001	3.88	.833	5.80	.816	-1.92	1.12	<0.001	0.004
7	3.84	.688	4.92	1.077	-1.08	1.26	.001	3.92	.702	5.88	.781	-1.96	1.17	<0.001	0.001
8	3.80	.707	4.76	1.128	-0.96	1.24	.002	3.88	.781	3.96	.735	-0.08	0.91	.642	0.004
9	3.96	.841	4.16	.624	-0.20	0.96	.335	3.92	.954	5.48	.823	-1.56	1.12	<0.001	<0.001
10	3.88	.666	5.68	.900	-1.80	1.12	<0.001	4.04	.676	5.56	.821	-1.52	0.96	<0.001	0.58
11	3.88	.726	5.44	.961	-1.56	1.04	<0.001	3.80	.707	5.68	.852	-1.88	1.13	<0.001	0.33
12	3.76	.723	5.40	.913	-1.64	1.19	<0.001	4.00	.645	5.60	.866	-1.60	1.08	<0.001	0.43
13	3.84	.746	5.48	.872	-1.64	1.19	<0.001	3.84	.746	4.00	.707	-0.16	1.11	.479	<0.001
14	3.80	.707	5.40	.816	-1.60	1.22	<0.001	3.68	.627	5.64	.810	-1.96	1.06	<0.001	0.36
15	3.68	.690	5.40	.957	-1.72	1.40	<0.001	4.00	.645	5.56	1.003	-1.56	1.12	<0.001	0.42
16	3.88	.666	2.56	.870	1.32	1.14	<0.001	3.80	.764	2.80	.764	1.00	1.04	.001	0.31
17	3.68	.748	2.64	.757	1.04	1.06	<0.001	3.84	.688	2.60	.764	1.24	1.09	<0.001	0.89
final grades	3.80	0.16	5.00	0.25	-1.2	0.32	<0.001	3.86	0.17	4.93	0.16	-1.07	0.24	<0.001	00.37

Removable thermoplastic appliances for treating moderate malocclusion problems gradually replace traditional fixed brackets. Mechanical interactions between prepared anatomical shapes and device models are simulated through finite element analysis. [14] The author believes that in this type of Removable device, most of the school of thought of fixed treatments prevails, and the mobile metal components settings have not been given due attention. In virtual space and computers, modeling for changes and displacement of teeth is facilitated. Unlike the non-wax typodont, in questions 4 and 5, in the virtual typodont, quality and satisfactory learning were not achieved in adjusting the C-clasp and labial bows. It is obvious that in this and similar environment, teaching the practical skill of wire bending is less effective. Still, it is possible to prepare steps for moving thermoplastic devices and numerical analysis through finite elements with acceptable quality.

The evaluation of the documentation quality of orthodontic tables shows poor compliance of Clinical examination with the documentation criteria of completed orthodontic tables Based on the established guidelines. Auditing should be repeated after providing opportunities for learning and self-critical analysis. [15] It was also found in the University of Bristol that there was no change in the proportion of simple and complex cases referred during the 8 years. However, the proportion of patients receiving complex treatment has significantly increased nowadays. [16] It has been recommended that treatment of straightforward cases with removable orthodontic appliances should be done by a general dentist [17, 18], but how? And why these problems have not yet been solved. The response from the students of the present study confirms the Bristol research results. [17] In the practical orthodontic scoring system, British researchers have concluded that all scoring should be done "blind" if possible. Secondly, it is necessary that after starting, grading should be finished without interruption .[19] Of course, it should be mentioned that dental students are applying for more practical training.[20] A questionnaire and an explanatory letter were mailed to all EURO-QUAL BIOMED II project members. After examining the questionnaire, it was concluded that orthodontics comprises a small part of the dental curriculum in most countries. Emphasis is on theory and clinical work; removable devices, functional devices, and specific aspects of fixed devices are taught in most countries. [21] In comparing Liverpool and Toronto dental schools, removable orthodontics treatments were more common in Liverpool than in Toronto. [22]

A study was conducted on orthodontic wire bending skills in Malaysia. The aim was to investigate students' perception of Flipped Classrooms compared to Live Demonstrations in transferring the skills of wire bending for removable orthodontic devices. [23] The first phase of orthodontic treatment, which is removable, is clinically and financially beneficial. [24] Student training can be expanded into short skill courses for general dentists, ideally with an advanced clinical course for those interested. [25] The education program in Lithuania usually leads to the extraction, the control of root movements, the treatment of young children, and the provision of dental prostheses to patients. [26] Guidelines for protecting the clinical content and evaluating students in orthodontic courses in general

dentistry in British dental schools are needed to maintain standards. [27] Therefore, perhaps the provision of non-wax and virtual typodonts can play an important role in improving the standard of education. The Students' Questionnaire Results in the present study confirms this point.
Continuous formative assessment may enhance students' learning of orthodontic wire-bending skills. To investigate the effect of formative evaluation on teaching practical dental skills, conducting more studies with a control group is recommended. [28]

Conclusion

Including non-wax or virtual typodont in the orthodontic education curriculum is an undeniable necessity. The student's satisfaction with non-wax typodont was significantly high and was very effective in their education. Eliminating the unexpected deficiencies in the pre-clinic is very beneficial in upgrading the standards of providing treatment at clinic. The possibility of displaying tissue responses in the software environment is of great help to students with a more profound understanding of orthodontic biomechanics. Also, virtual typodont is essential in satisfying students and tutors in improving mobile practical orthodontic education levels.

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Conflict of Interest

No Conflict of Interest Declared ■

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