Development of a Systematic Course On Orthodontic Temporary Anchorage Devices (TADs) for Orthodontic Residency Program

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Abstract

Background: Orthodontic temporary anchorage devices (TADs) offer absolute anchorage for clinical orthodontics. No systematic course on TADs has been described so far. The objectives of this study were to develop a systematic course on orthodontic TADs and to determine its teaching outcome.

Methods: Five modules (fundamentals, anatomic sites, clinical applications, complications and insertion techniques, FACCI) were designed in this FACCI course on TADs. A total of 61 orthodontic graduate students from Department of Orthodontics, West China Hospital of Stomatology, Sichuan University were enrolled in this study. Baseline levels on the use of TADs were surveyed through a before-course questionnaire and the teaching outcomes were assessed through an after-course questionnaire.

Results: After the course, significantly more students were willing to insert TADs by themselves ($p<0.001$). Students were significantly more familiar with the clinical applications of TADs for different types of tooth movements ($p<0.001$) and the insertion techniques of TADs at different anatomic sites ($p<0.001$). Before the course, most of the students had no knowledge on addressing TADs-associated complication and they were significantly more familiar with the techniques and skills of addressing TADs-associated complication after the course ($p<0.001$).

Conclusions: The FACCI course on orthodontic TADs was effective and promoted the clinical applications of TADs in clinical practice among orthodontic graduate students.

Background

Since the concept of orthodontic temporary anchorage devices (TADs) was introduced in 1945,(1) TADs have been expanding the scope of orthodontic treatments.(2–4) Due to their safety and clinical effectiveness, TADs have been well accepted by both orthodontists and patients.(5) TADs are used for multiple purposes, including anterior retraction, molar distalization, molar protraction, intrusion, traction of impacted teeth, multidisciplinary approaches, etc.(6, 7) Of particular, the most widely clinical application of mini-implants is anterior en-masse retraction and molar anchorage preservation for bimaxillary protrusive patients with premolar extractions.(8) Enthusiastic practitioners have been expanding the clinical applications of orthodontic mini-implants, e.g., anterior intrusion for gummy smile, rapid maxillary bony expansion and large-scale protraction of mandibular molars.(9–11) Moreover, deeply-impacted mandibular molars could be easily and efficiently managed through mini-implants at mandibular ramus regions.(4) Thus, being absolute anchorage for orthodontic treatments, TADs are versatile in treating a variety of challenging patients with minimal undesirable tooth movements.(12–15)

However, it was reported that many orthodontists did not use TADs in their clinical practice due to lack of education and training on TADs.(16) Although the clinical application of TADs has been incorporated into orthodontic residency programs in many dental schools, the education and training on TADs are not available in all dental schools, leading to an educational inequality of orthodontic TADs among different countries and regions.(17) Moreover, no systematic course on TADs for orthodontic residency program has been published so far.

Therefore, the aims of this study were to develop a systematic course on TADs for orthodontic residency program and to determine its effectiveness on clinical applications of TADs among orthodontic graduate students.

Methods

Development of a course on orthodontic TADs

As displayed in Fig. 1, the curriculum on orthodontic TADs was designed and developed before the course. Specifically, the course included five modules, i.e., fundamentals of orthodontic TADs, anatomic sites available for orthodontic TADs, clinical applications of orthodontic TADs, complications associated with orthodontic TADs and insertion technique of orthodontic TADs. The first four modules were didactic while the last module was practical hands-on workshop of inserting TADs at different anatomic sites on skull models.

For the first module (fundamentals of orthodontic TADs), the knowledge on history, development, advantages, disadvantages and characteristics of orthodontic TADs was taught through didactic lectures.

For the second module (anatomic sites available for orthodontic TADs), ten frequently-used anatomic sites available for orthodontic TADs together with their individual anatomic features were included. Moreover, different types, diameters and lengths of TADs for different anatomic sites were demonstrated.

For the third module (clinical applications of orthodontic TADs), locations of TADs, biomechanics and clinical cases for each of the twelve clinical applications of orthodontic TADs were included.

For the fourth module (complications associated with orthodontic TADs), four frequently-encountered complications of orthodontic TADs were included. Clinical manifestation, mechanisms or pathogenesis, clinical trouble-shooting skills and prevention were demonstrated for each complication.

The fifth module (insertion techniques) was executed through hands-on practice of inserting TADs at different anatomic sites. Specifically, the specific areas, insertion techniques and insertion tips were demonstrated to the students and the students practiced the insertion of TADs on skull models under the supervision of the course developer (HL).

Participants

Orthodontic graduate students from the Department of Orthodontics, West China Hospital of Stomatology, Sichuan University attended this course. Both before- and after-course questionnaire survey (Table 1 & Table 2) was completed.

Table 1
Before-course questionnaire.

Before-course questionnaire					
Q1 Name					
Q2 Gender					
Male	Female				
Q3 Age					
Q4 Grade					
First year	Second year	Third year			
Q5 Do you use implant anchors for orthodontic treatment?					
Yes	No				
Q6 Who usually implant the patient's implant anchor?					
Myself	Supervisor	Oral surgeon		Other	
Q7 How often do you use implant anchors in fixed appliance?					
0%	100%				
Q8 How often do you use implant anchors in clear aligner?					
0%	100%				
Q9 You are familiar with the insertion techniques of orthodontic TADs at the following anatomic sites:					
Anatomic site	Strongly disagree	Disagree	Neutral	Agree	Very agree
Maxillary anterior interradicular region					
Maxillary posterior interradicular region					
Anterior nasal spine					
Infrazygomatic spine					
Maxillary tuberosity					
Palatal region					
Mandibular anterior interradicular region					
Mandibular posterior interradicular region					
Mandibular symphysis					
Mandibular buccal shelf					
External oblique ridge					
Mandibular ramus					

Before-course questionnaire

Q10 Your frequency of using implant anchors in the following tooth movements:

Tooth movement	Strongly low	Low	Neutral	High	Strongly high
Anterior en-masse retraction for extraction patients					
Molar distalization					
Molar protraction					
Molar uprighting					
Molar intrusion					
Intrusion of incisors					
Maxillary protraction					
Mini-implant supported maxillary expansion					
Orthodontic traction of impacted teeth					
Open bite					
Occlusal canting					
Temporary prosthesis for missing teeth among teenagers					

Q11 Your demand for implant anchorage in the following tooth movement:

Tooth movement	Strongly low	Low	Neutral	High	Strongly high
Anterior en-masse retraction for extraction patients					
Molar distalization					
Molar protraction					
Molar uprighting					
Molar intrusion					
Intrusion of incisors					
Maxillary protraction					
Mini-implant supported maxillary expansion					
Orthodontic traction of impacted teeth					
Open bite					
Occlusal canting					

Before-course questionnaire					
Temporary prosthesis for missing teeth among teenagers					
Q12 You are familiar with the complications of implant anchorage:					
Complication	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Root contact					
Mini-implant fractures					
Soft tissue inflammation					
Mini-implant loosening					
Q13 The neccessity of your willing to learn about the treatment of complications of implant anchorage:					
Complication	Strongly unnecessary	Unnecessary	Neutral	Necessary	Strongly necessary
Root contact					
Mini-implant fractures					
Soft tissue inflammation					
Mini-implant loosening					

Table 2
After-course questionnaire.

After-course questionnaire					
Q1 Name					
Q2 Gender					
Male Female					
Q3 Age					
Q4 Grade					
First year Second year Third year					
Q5 Do you use implant anchors for orthodontic treatment in future?					
Yes No					
Q6 Who will implant the patient's implant anchor in future?					
Myself Supervisor Oral surgeon Other					
Q7 You are familiar with the insertion techniques of orthodontic TADs at the following anatomic sites after the course:					
Anatomic site	Strongly disagree	Disagree	Neutral	Agree	Very agree
Maxillary anterior interradicular region					
Maxillary posterior interradicular region					
Anterior nasal spine					
Infrazygomatic spine					
Maxillary tuberosity					
Palatal region					
Mandibular anterior interradicular region					
Mandibular posterior interradicular region					
Mandibular symphysis					
Mandibular buccal shelf					
External oblique ridge					
Mandibular ramus					
Q8 You are familiar with the insertion techniques of orthodontic TADs in tooth movements after the course:					
Tooth movement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree

After-course questionnaire					
Anterior en-masse retraction for extraction patients					
Molar distalization					
Molar protraction					
Molar uprighting					
Molar intrusion					
Intrusion of incisors					
Maxillary protraction					
Mini-implant supported maxillary expansion					
Orthodontic traction of impacted teeth					
Open bite					
Occlusal canting					
Temporary prosthesis for missing teeth among teenagers					
Q9 Your demand for implant anchorage in the following tooth movement after the course:					
Tooth movement	Strongly low	Low	Neutral	High	Strongly high
Anterior en-masse retraction for extraction patients					
Molar distalization					
Molar protraction					
Molar uprighting					
Molar intrusion					
Intrusion of incisors					
Maxillary protraction					
Mini-implant supported maxillary expansion					
Orthodontic traction of impacted teeth					
Open bite					
Occlusal canting					
Temporary prosthesis for missing teeth among teenagers					

After-course questionnaire					
Q10 You are familiar with the complications of implant anchorage:					
Complication	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Root contact					
Mini-implant fractures					
Soft tissue inflammation					
Mini-implant loosening					

Questionnaires

This questionnaire survey was filled out for both before and after the course (Table 1 & Table 2). Specifically, before the course, the students were asked to complete the before-course survey that included demographic information (name, gender and age) and baseline level of using orthodontic TADs in clinical practice. After the course, the after-course survey was completed by the students.

The answers to the questionnaire were dichotomous (e.g., gender), continuous (e.g., age) and scale (e.g., strongly disagree, disagree, neutral, agree and strongly agree) data. The answers to the five-scale data were transformed into numeric data through Likert scale principle.(18, 19)

Statistical analysis

The statistical analyses were conducted in SPSS 26.0 (SPSS Inc., Chicago, Illinois, USA) and GraphPad Prism 8.4. (Graphpad Prism, California, USA). Chi-square analysis, one-way analysis of variance and two-way analysis of variance are used. A p value less than 0.05 was considered as statistical significance.

Results

Demographic characteristics of participants

A total of 61 students attended this course and took part in the survey. The mean age was 28.4 ± 6.4 yrs old, with a female predominance (47/61). The majority of them were in the first year (59/61) with two students in their second year.

Orthodontic TADs in clinical practice

Before the course, 41 students (67.2%) reported that they used TADs in their clinical practice. As shown in Fig. 2, the proportion of students who would use TADs in clinical practice was significantly higher after the course than before the course ($p < 0.001$), with 98.4% of the students reporting that they would use TADs in their future practice. Moreover, TADs were applied among 25.8 ± 20.0% of orthodontic patients receiving fixed appliances and among 23.2 ± 21.7% of orthodontic patients receiving clear aligner, with no significant difference between the two treatment modalities ($p > 0.05$).

In clinical practice, TADs were inserted by students themselves (16.4%), clinical supervisors (75.4%) and oral surgeons (8.2%). After the course, the students reported that the TADs would be inserted by students themselves (47.5%), clinical supervisors (47.5%) and oral surgeons (4.9%). The chi-square test revealed that the proportion of students who inserted or would insert TADs was significantly different between before and after the course ($p < 0.001$), with more students being willing to insert TADs by themselves.

Insertion techniques of TADs

As displayed in Fig. 3, before the course, students were most familiar with the insertion of TADs at maxillary posterior interradicular region (2.25 ± 1.25) while were least familiar with inserting TADs at anterior nasal spine (1.31 ± 0.53) ($p < 0.001$). Following the course, the students reported that they were significantly more familiar with the insertion techniques at all the anatomical sites ($p < 0.001$), with the most familiar insertion site being maxillary posterior interradicular region (3.92 ± 0.56) and the least familiar site being maxillary tuberosity (2.82 ± 1.15).

Clinical applications of TADs for different types of tooth movements

As displayed in Table 3, the frequency of applying TADs differed significantly among different types of orthodontic tooth movements ($p < 0.001$). Among them, TADs were most frequently used for anterior en-masse retraction (3.74 ± 1.05) and molar distalization (3.69 ± 1.22) while were least frequently used for molar protraction (2.77 ± 1.13) and temporary prosthesis (2.49 ± 1.21).

Table 3
The frequency of applying TADs among different types of orthodontic tooth movements.

Anatomic site	1 = Strongly low N (%)	2 = Low N (%)	3 = Neutral N (%)	4 = High N (%)	5 = Strongly high N (%)	Average	F	P value
Anterior en-masse retraction	6 (9.8%)	0 (0%)	7 (11.5%)	39 (63.9%)	9 (14.8%)	3.74 ± 1.05	5.955	0.000
Molar distalization	7 (11.5%)	2 (3.3%)	9 (14.8%)	28 (45.9%)	15 (24.6%)	3.69 ± 1.22		
Molar intrusion	7 (11.5%)	2 (3.3%)	18 (29.5%)	28 (45.9%)	6 (9.8%)	3.39 ± 1.10		
Intrusion of incisors	7 (11.5%)	6 (11.5%)	21 (34.4%)	21 (34.4%)	6 (9.8%)	3.21 ± 1.13		
Molar uprighting	7 (11.5%)	7 (11.5%)	22 (36.1%)	20 (32.8%)	5 (8.2%)	3.15 ± 1.11		
Occlusal Canting	10 (16.4%)	4 (6.6%)	21 (34.4%)	20 (32.8%)	6 (9.8%)	3.13 ± 1.20		
Orthodontic traction of impacted teeth	9 (14.8%)	6 (9.8%)	23 (37.7%)	17 (27.9%)	6 (9.8%)	3.08 ± 1.17		
Maxillary protraction	10 (16.4%)	7 (11.5%)	24 (39.3%)	15 (24.6%)	5 (8.2%)	2.97 ± 1.17		
Mini-implant supported maxillary expansion	11 (18.0%)	6 (9.8%)	25 (41.0%)	13 (21.3%)	6 (9.8%)	2.95 ± 1.20		
Open bite	10 (16.4%)	10 (16.4%)	25 (41.0%)	11 (18.0%)	5 (8.2%)	2.85 ± 1.15		
Molar protraction	9 (14.8%)	15 (24.6%)	23 (37.7%)	9 (14.8%)	5 (8.2%)	2.77 ± 1.13		
Temporary prosthesis	16 (26.2%)	15 (24.6%)	18 (29.5%)	8 (13.1%)	4 (6.6%)	2.49 ± 1.21		
Total	109 (14.9%)	80 (10.9%)	236 (32.2%)	229 (31.3%)	78 (10.7%)	3.12 ± 1.20		

As displayed in Fig. 4, before the course, the students reported that TADs were mostly required for molar distalization (4.20 ± 0.63) and anterior en-masse retraction (4.07 ± 0.68) while least required for molar protraction (3.23 ± 1.01) and temporary prosthesis (3.02 ± 1.04). The scales of the need of TADs for different types of orthodontic tooth movements were similar between before and after curriculum ($p > 0.05$), except for molar protraction (3.23 ± 1.01 vs. 3.82 ± 0.53, $p = 0.008 < 0.05$).

Complications associated with TADs

Before the course, students were not familiar with the technique and skills on how to address complications associated with TADs (Table 4) and most of the orthodontic students (72.1%) reported that learning the technique and skills of addressing TADs-associated complications were highly necessary (Table 5). After the curriculum, orthodontic students were significantly more familiar with the techniques and skills of addressing TADs-associated complications (all $p < 0.001$).

Table 4
Familiarity with the technique and skills on how to address complications associated with TADs.

Complication	1 = Strongly disagree N (%)	2 = Disagree N (%)	3 = Neutral N(%)	4 = Agree N (%)	5 = Strongly agree N (%)	Average	P Value
Root contact -before	13 (21.3%)	10 (16.4%)	17 (27.9%)	18 (29.5%)	3 (4.9%)	2.80 ± 1.22	0.000
Root contact -after	0 (0%)	0 (0%)	7 (11.5%)	42 (68.9%)	12 (19.7%)	4.08 ± 0.56	
Mini-implant fractures -before	14 (23.0%)	12 (19.7%)	20 (32.8%)	13 (21.3%)	2 (3.3%)	2.62 ± 1.16	0.000
Mini-implant fractures -after	0 (0%)	0 (0%)	9 (14.8%)	43 (70.5%)	9 (14.8%)	4.00 ± 0.55	
Soft tissue inflammation-before	8 (13.1%)	13 (21.3%)	17 (27.9%)	18 (29.5%)	5 (8.2%)	2.98 ± 1.18	0.000
Soft tissue inflammation-after	0 (0%)	0 (0%)	7 (11.5%)	42 (68.9%)	12 (19.7%)	4.08 ± 0.56	
Mini-implant loosening -before	10 (16.4%)	12 (19.7%)	15 (24.6%)	18 (29.5%)	6 (9.8%)	2.97 ± 1.25	0.000
Mini-implant loosening -after	0 (0%)	0(0%)	8 (13.1%)	41 (67.2%)	12 (19.7%)	4.07 ± 0.57	
Total-before	45 (18.4%)	47(19.3%)	69 (28.3%)	67 (27.5%)	16 (6.6%)	2.84 ± 1.20	0.000
Total-after	0(0%)	0(0%)	31 (12.7%)	168 (68.9%)	45 (18.4%)	4.06 ± 0.56	

Table 5
Willingness to learn the technique and skill on how to address complications associated with miniscrews.

Complication	1 = Strongly unnecessary N (%)	2 = Unnecessary N (%)	3 = Neutral N (%)	4 = Necessary N (%)	5 = Strongly necessary N (%)	Average	F	P Value
Root contact	0 (0%)	0 (0%)	3 (4.9%)	15 (24.6%)	43 (70.5%)	4.66± 0.57	0.154	0.92
Mini-implant fractures	0 (0%)	0 (0%)	2 (3.3%)	15 (24.6%)	44 (72.1%)	4.69± 0.53		
Soft tissue inflammation	0 (0%)	0 (0%)	2 (3.3%)	15 (24.6%)	44 (72.1%)	4.69± 0.53		
Mini-implant loosening	0 (0%)	0 (0%)	1 (1.6%)	15 (24.6%)	45 (73.8%)	4.72± 0.49		
Total	0 (0%)	0 (0%)	8 (3.3%)	60 (24.6%)	176 (72.1%)	4.69± 0.53		

Discussion

Orthodontic TADs, including miniscrews, mini-implants and miniplates, are commonly used in clinical practice to offer absolute anchorage for orthodontic or orthopedic purposes.(7, 20) Since the introduction of orthodontic TADs into orthodontic residency programs in 2005,(17) more and more orthodontists have been using orthodontic TADs in their practice to facilitate orthodontic tooth movement. A recent survey revealed that early attending courses on orthodontic TADs may improve students' clinical problem-solving skills.(21) In 2008, we initiated clinical courses on orthodontic TADs where students learned how to insert and use TADs for orthodontic purposes at the Department of Orthodontics, West China Hospital of Stomatology, Sichuan University. However, a systematic course on orthodontic TADs was not available until 2018 when a systematic TADs course was incorporated into orthodontic graduate didactic education program. The "FACCI" TADs course included four didactic sessions and one hands-on session. Specifically, the didactic sessions included fundamentals of orthodontic TADs, available anatomic sites for TADs, clinical applications of TADs and complications associated with TAD. Moreover, in the hands-on session, the insertion techniques of TADs at different anatomic sites were demonstrated to the students and the students practiced these skills on skull models.

Before the TADs course, about 67.2% graduate students reported that they used TADs in their practice. This proportion (67.2%) is similar to that for private practitioners (69%) in US while smaller than that for orthodontic residents (83%).(17) In contrast, after the course, 98.4% of the students reported that they would use TADs in their practice. Moreover, only a small proportion (16.4%) of students placed orthodontic TADs by themselves, with a majority (75.4%) of students having their patients' TADs placed by their clinical supervisors. In contrast, after the course, about one half of students (47.5%) would insert TADs by themselves. These findings could be attributed to the phenomenon that lack of education and training is a major cause for not using orthodontic TADs in clinical practice.(16) In effect, we found that the students were more familiar with the insertion techniques of orthodontic TADs after the course (Fig. 3).

With the development of orthodontic materials and advances in orthodontic techniques, clear aligner appeals to orthodontic patients for its comfort and ease of oral hygiene care.(22, 23) A recent treatment-difficulty evaluation system on clear aligner revealed that clear aligner had its distinct biochemical system and different types of difficult tooth movements as compared to fixed appliances,(24) suggesting that clear aligner may require more additional anchorage than fixed appliances. A recent finite-element study revealed that an anterior inter-radicular miniscrew between central incisors was effective for incisor intrusion and palatal torquing during anterior retraction.(25) However, we found that the percentage of orthodontic patients was similar between aligner patients (23.2%) and fixed patients (25.8%).

It was reported that the most frequently use of TADs was for anterior en-masse retraction and the augmentation of posterior anchorage.(17) In addition to anterior en-masse retraction, TADs are commonly used for molar distalization. (5) Consistently, in the present study, we found that TADs were most frequently used for anterior en-masse retraction and molar distalization. For anterior en-masse retraction, TADs are often placed at maxillary posterior interradicular regions (for sagittal control) and maxillary anterior interradicular region (for vertical control of incisors). This could explain the phenomenon that the students were most familiar with the insertion technique of TADs at maxillary posterior interradicular region and maxillary anterior interradicular region. Moreover, the two aforementioned regions are easier to place TADs due to ease of operation and good surgical view as compared to the two least familiar anatomic sites, i.e., anterior nasal spine and mandibular ramus. The insertion of TADs at anterior nasal spine is indicated for patients who require large-scale incisor intrusion with limited interradicular space. For the insertion of TADs at anterior nasal spine, flap reflection is required to expose the anterior nasal spine and extension hooks may be needed for the ease of force application, which is more difficult and technique-sensitive than placing TADs at interradicular regions. The insertion of TADs at mandibular ramus is often indicated for orthodontic patients with impacted mandibular molars.(4, 7) The procedures of placing TADs at the ramus region is very difficult. It requires tough flap reflection and pre-drilling due to medial pterygoid muscle lying on the ramus region and thick and high-density cortex. Despite the difficult insertion technique associated with these regions, through the hands-on module, students were significantly more familiar with the insertion technique at all the anatomic sites especially the anterior nasal spine and the mandibular ramus region.

We found that TADs were least frequently used for molar protraction and temporary prosthesis in clinical practice among the students. This may be attributed to the fact that fewer patients require molar protraction or temporary prosthesis as compared to other types of orthodontic tooth movement. Moreover, molar protraction with the aid of TADs requires meticulous biomechanical design and prolonged treatment duration,(11, 26) rendering patients to choose implant prosthesis instead of molar protraction for missing molar space.

We found that the scales of need of TADs for different tooth movements were high for both before (range: 3.0-4.2) and after (range: 3.3–4.1) the course, suggesting that TADs are important adjuncts for efficient orthodontic tooth movements in orthodontic practice. Interestingly, the scales of need of TADs for different tooth movements were similar between before and after the course, except for molar protraction. Since TADs were least frequently used for molar protraction before the course, the need of TADs for molar protraction was not high. Demonstration of clinical cases of successful molar protraction in this course fostered students to develop confidence on protracting molars with TADs, resulting in higher scale of need of TADs for molar protraction after the course.

Despite the clinical effectiveness of TADs, orthodontic TADs are still associated with several complications or adverse effects, e.g., root contact, facture of TADs, soft tissue inflammation and loosening.(27, 28) The incidence of these complications was low in clinical practice, especially fracture of TADs, which could explain why students were not familiar with the skills of addressing complications associated with TADs. Moreover, root contact or perforation by

orthodontic TADs requires multidisciplinary treatments,(29) which is beyond the skills mastered by the graduate students. Thus, learning the skills of addressing these complications was highly needed before the course. After the course, the students reported that they were more familiar with the skills of addressing complications associated with TADs, indicating that objectives of the course on TADs was achieved.

Conclusion

The course on orthodontic TADs that included fundamentals, anatomic sites, clinical applications, complications and insertion techniques (FACCI) was effective and promoted the clinical applications of TADs among orthodontic graduate students.

Abbreviations

TADs: temporary anchorage devices

FACCI: fundamentals, anatomic sites, clinical applications, complications and insertion techniques,

Declarations

Acknowledgements

Not applicable.

Authors' contributions

All authors participated in the writing of the article and participated in the course. ZT and YG made substantial contributions to the conception and wrote the main manuscript. YC and HL made design of the work and drew the pictures. LP, LL and XL made questionnaires and made interpretation of the data. FJ and YW mainly analyzed the data and made the tables. WL and HL substantively revised it. All authors approved the submitted version.

Availability of data and materials

The datasets used and analysed during the current study are available from the corresponding author on reasonable request.

All methods were performed in accordance with the relevant guidelines and regulations.

Ethics approval and conscent to participate

The project was approved by the Ethical Committee at the West China Hospital of Stomatology of Sichuan University (protocol No. WCHSIRB-CT-2020-150), and participants were informed before they were included in the study. And all informed conscent was obtained from all individual participants included in the study.

Conscent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests

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References

1. Gainsforth BL, Higley LB. A study of orthodontic anchorage possibilities in basal bone. Am J Orthod Oral Surg. 1945;31(8):406–17.
2. Lyu XW, Guo JS, Chen LR, Gao Y, Liu L, Pu LL, et al. Assessment of available sites for palatal orthodontic mini-implants through cone-beam computed tomography. Angle Orthodontist. 2020;90(4):516–23.
3. El-Dawlatly MM, Abou-El-Ezz AM, El-Sharaby FA, Mostafa YA. Zygomatic mini-implant for Class II correction in growing patients. J Orofac Orthop. 2014;75(3):213–25.
4. Chang CH, Lin JS, Roberts WE. Ramus screws: the ultimate solution for lower impacted molars. Seminars in orthodontics. 2018;24(1):135–54.
5. Markic G, Katsaros C, Pandis N, Eliades T. Temporary anchorage device usage: a survey among Swiss orthodontists. Prog Orthod. 2014;15(1):29.
6. Hyde JD, King GJ, Greenlee GM, Spiekerman C, Huang GJ. Survey of orthodontists' attitudes and experiences regarding miniscrew implants. J Clin Orthod. 2010;44(8):481–6.
7. Zhou J, Hong H, Zhou H, Hua C, Yang Z, Lai W, et al. Orthodontic extraction of a high-risk impacted mandibular third molar contacting the inferior alveolar nerve, with the aid of a ramus mini-screw. Quintessence Int. 2021;52(6):538–46.
8. Papadopoulos MA, Papageorgiou SN, Zogakis IP. Clinical effectiveness of orthodontic miniscrew implants: a meta-analysis. J Dent Res. 2011;90(8):969–76.
9. Kaku M, Kojima S, Sumi H, Koseki H, Abedini S, Motokawa M, et al. Gummy smile and facial profile correction using miniscrew anchorage. Angle Orthod. 2012;82(1):170–7.
10. Song KT, Park JH, Moon W, Chae JM, Kang KH. Three-dimensional changes of the zygomaticomaxillary complex after mini-implant assisted rapid maxillary expansion. Am J Orthod Dentofacial Orthop. 2019;156(5):653–62.
11. Baik UB, Kim MR, Yoon KH, Kook YA, Park JH. Orthodontic uprighting of a horizontally impacted third molar and protraction of mandibular second and third molars into the missing first molar space for a patient with posterior crossbites. Am J Orthod Dentofacial Orthop. 2017;151(3):572–82.
12. Sosly R, Mohammed H, Rizk MZ, Jamous E, Qaisi AG, Bearn DR. Effectiveness of miniscrew-supported maxillary incisor intrusion in deep-bite correction: A systematic review and meta-analysis. Angle Orthod. 2020;90(2):291–304.
13. Noh MK, Kim YJ, Chung KR, Kim SH, Nelson G. Corticotomy With a Palatal Bone-Borne Retractor for Correcting Severe Bimaxillary Protrusion. J Craniofac Surg. 2018;29(1):e64-e8.
14. Seo YJ, Lin L, Kim SH, Chung KR, Nelson G. Strategic camouflage treatment of skeletal Class III malocclusion (mandibular prognathism) using bone-borne rapid maxillary expansion and mandibular anterior subapical osteotomy. Am J Orthod Dentofacial Orthop. 2016;149(1):114–26.
15. Eimar H. Orthodontic miniscrew implants usually are clinically effective to minimize undesirable tooth movements. Journal of the American Dental Association (1939). 2015;146(3):203-4.

16. Fatani EJ, Eskandrani RM, Alfadil LO. Use of orthodontic mini-screws among orthodontists in Saudi Arabia. Int J Res Med Sci. 2019;7(4):1150–5.
17. Shirck JM, Firestone AR, Beck FM, Vig KW, Huja SS. Temporary anchorage device utilization: comparison of usage in orthodontic programs and private practice. Orthodontics: the art and practice of dentofacial enhancement. 2011;12(3):222–31.
18. Tijmstra J, Bolsinova M, Jeon M. General mixture item response models with different item response structures: Exposition with an application to Likert scales. Behavior research methods. 2018;50(6):2325–44.
19. Zhang X, Savalei V. Improving the Factor Structure of Psychological Scales: The Expanded Format as an Alternative to the Likert Scale Format. Educational and psychological measurement. 2016;76(3):357–86.
20. Garib D, Pugliese F, Kato RM, Faco R, Yatabe M, Timmerman H, et al. Bone-anchored maxillary protraction long-term outcomes in UCLP. Angle Orthod. 2020;90(5):734–41.
21. Abu Al-Melh MM, Al-Anzi AN. Knowledge of undergraduate dental students toward orthodontic skeletal temporary anchorage devices at Kuwait University. BMC Med Educ. 2020;20(1):340.
22. Gao M, Yan X, Zhao R, Shan Y, Chen Y, Jian F, et al. Comparison of pain perception, anxiety, and impacts on oral health-related quality of life between patients receiving clear aligners and fixed appliances during the initial stage of orthodontic treatment. Eur J Orthod. 2020.
23. Zhao R, Huang R, Long H, Li Y, Gao M, Lai W. The dynamics of the oral microbiome and oral health among patients receiving clear aligner orthodontic treatment. Oral diseases. 2020;26(2):473–83.
24. Long H, Wu Z, Yan X, Wang Q, Liu L, Wang Y, et al. An objective system for appraising clear aligner treatment difficulty: clear aligner treatment complexity assessment tool (CAT-CAT). BMC Oral Health. 2020;20(1):312.
25. Liu L, Zhan Q, Zhou J, Kuang Q, Yan X, Zhang X, et al. Effectiveness of an anterior mini-screw in achieving incisor intrusion and palatal root torque for anterior retraction with clear aligners: A finite element study. Angle Orthod. 2021:[in press].
26. Baik UB, Bayome M, Abbas NH, Park JH, Lee UL, Kim YJ. Factors associated with spontaneous angular changes of impacted mandibular third molars as a result of second molar protraction. Am J Orthod Dentofacial Orthop. 2019;156(2):178–85.
27. Giudice AL, Rustico L, Longo M, Oteri G, Papadopoulos MA, Nucera R. Complications reported with the use of orthodontic miniscrews: A systematic review. Korean J Orthod. 2021;51(3):199–216.
28. Franzotti Sant'Anna E, Carneiro da Cunha A, Paludo Brunetto D, Franzotti Sant'Anna C. Camouflage of a high-angle skeletal Class II open-bite malocclusion in an adult after mini-implant failure during treatment. Am J Orthod Dentofacial Orthop. 2017;151(3):583–97.
29. McCabe P, Kavanagh C. Root perforation associated with the use of a miniscrew implant used for orthodontic anchorage: a case report. Int Endod J. 2012;45(7):678–88.

Tables

Table 1. Before-course questionnaire.

Before-course questionnaire						
Q1 Name						
Q2 Gender						
Male	Female					
Q3 Age						
Q4 Grade						
First year	Second year	Third year				
Q5 Do you use implant anchors for orthodontic treatment?						
Yes	No					
Q6 Who usually implant the patient's implant anchor?						
Myself	Supervisor	Oral surgeon	Other			
Q7 How often do you use implant anchors in fixed appliance?						
0%	100%					
Q8 How often do you use implant anchors in clear aligner?						
0%	100%					
Q9 You are familiar with the insertion techniques of orthodontic TADs at the following anatomic sites:						
Anatomic site	Strongly disagree	Disagree	Neutral	Agree	Very agree	
Maxillary anterior interradicular region						
Maxillary posterior interradicular region						
Anterior nasal spine						
Infrazygomatic spine						
Maxillary tuberosity						
Palatal region						
Mandibular anterior interradicular region						
Mandibular posterior interradicular region						
Mandibular symphysis						
Mandibular buccal shelf						
External oblique ridge						
Mandibular ramus						
Q10 Your frequency of using implant anchors in the following tooth movements:						

Before-course questionnaire

Tooth movement	Strongly low	Low	Neutral	High	Strongly high
Anterior en-masse retraction for extraction patients					
Molar distalization					
Molar protraction					
Molar uprighting					
Molar intrusion					
Intrusion of incisors					
Maxillary protraction					
Mini-implant supported maxillary expansion					
Orthodontic traction of impacted teeth					
Open bite					
Occlusal canting					
Temporary prosthesis for missing teeth among teenagers					

Q11 Your demand for implant anchorage in the following tooth movement:

Tooth movement	Strongly low	Low	Neutral	High	Strongly high
Anterior en-masse retraction for extraction patients					
Molar distalization					
Molar protraction					
Molar uprighting					
Molar intrusion					
Intrusion of incisors					
Maxillary protraction					
Mini-implant supported maxillary expansion					
Orthodontic traction of impacted teeth					
Open bite					
Occlusal canting					
Temporary prosthesis for missing teeth among teenagers					

Before-course questionnaire					
Q12 You are familiar with the complications of implant anchorage:					
Complication	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Root contact					
Mini-implant fractures					
Soft tissue inflammation					
Mini-implant loosening					
Q13 The neccessity of your willing to learn about the treatment of complications of implant anchorage:					
Complication	Strongly unnecessary	Unnecessary	Neutral	Necessary	Strongly necessary
Root contact					
Mini-implant fractures					
Soft tissue inflammation					
Mini-implant loosening					

Table 2. After-course questionnaire.

After-course questionnaire					
Q1 Name					
Q2 Gender					
Male Female					
Q3 Age					
Q4 Grade					
First year Second year Third year					
Q5 Do you use implant anchors for orthodontic treatment in future?					
Yes No					
Q6 Who will implant the patient's implant anchor in future?					
Myself Supervisor Oral surgeon Other					
Q7 You are familiar with the insertion techniques of orthodontic TADs at the following anatomic sites after the course:					
Anatomic site	Strongly disagree	Disagree	Neutral	Agree	Very agree
Maxillary anterior interradicular region					
Maxillary posterior interradicular region					
Anterior nasal spine					
Infrazygomatic spine					
Maxillary tuberosity					
Palatal region					
Mandibular anterior interradicular region					
Mandibular posterior interradicular region					
Mandibular symphysis					
Mandibular buccal shelf					
External oblique ridge					
Mandibular ramus					
Q8 You are familiar with the insertion techniques of orthodontic TADs in tooth movements after the course:					
Tooth movement	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Anterior en-masse retraction for extraction patients					

After-course questionnaire					
Molar distalization					
Molar protraction					
Molar uprighting					
Molar intrusion					
Intrusion of incisors					
Maxillary protraction					
Mini-implant supported maxillary expansion					
Orthodontic traction of impacted teeth					
Open bite					
Occlusal canting					
Temporary prosthesis for missing teeth among teenagers					
Q9 Your demand for implant anchorage in the following tooth movement after the course:					
Tooth movement	Strongly low	Low	Neutral	High	Strongly high
Anterior en-masse retraction for extraction patients					
Molar distalization					
Molar protraction					
Molar uprighting					
Molar intrusion					
Intrusion of incisors					
Maxillary protraction					
Mini-implant supported maxillary expansion					
Orthodontic traction of impacted teeth					
Open bite					
Occlusal canting					
Temporary prosthesis for missing teeth among teenagers					
Q10 You are familiar with the complications of implant anchorage:					

After-course questionnaire					
Complication	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
Root contact					
Mini-implant fractures					
Soft tissue inflammation					
Mini-implant loosening					

Table 3. The frequency of applying TADs among different types of orthodontic tooth movements.

Anatomic site	1 = Strongly low N (%)	2 = Low N (%)	3 = Neutral N (%)	4 = High N (%)	5 = Strongly high N (%)	Average	F	P value
Anterior en-masse retraction	6 (9.8%)	0 (0%)	7 (11.5%)	39 (63.9%)	9 (14.8%)	3.74 ± 1.05	5.955	0.000
Molar distalization	7 (11.5%)	2 (3.3%)	9 (14.8%)	28 (45.9%)	15 (24.6%)	3.69 ± 1.22		
Molar intrusion	7 (11.5%)	2 (3.3%)	18 (29.5%)	28 (45.9%)	6 (9.8%)	3.39 ± 1.10		
Intrusion of incisors	7 (11.5%)	6 (11.5%)	21 (34.4%)	21 (34.4%)	6 (9.8%)	3.21 ± 1.13		
Molar uprighting	7 (11.5%)	7 (11.5%)	22 (36.1%)	20 (32.8%)	5 (8.2%)	3.15 ± 1.11		
Occlusal Canting	10 (16.4%)	4 (6.6%)	21 (34.4%)	20 (32.8%)	6 (9.8%)	3.13 ± 1.20		
Orthodontic traction of impacted teeth	9 (14.8%)	6 (9.8%)	23 (37.7%)	17 (27.9%)	6 (9.8%)	3.08 ± 1.17		
Maxillary protraction	10 (16.4%)	7 (11.5%)	24 (39.3%)	15 (24.6%)	5 (8.2%)	2.97 ± 1.17		
Mini-implant supported maxillary expansion	11 (18.0%)	6 (9.8%)	25 (41.0%)	13 (21.3%)	6 (9.8%)	2.95 ± 1.20		
Open bite	10 (16.4%)	10 (16.4%)	25 (41.0%)	11 (18.0%)	5 (8.2%)	2.85 ± 1.15		
Molar protraction	9 (14.8%)	15 (24.6%)	23 (37.7%)	9 (14.8%)	5 (8.2%)	2.77 ± 1.13		
Temporary prosthesis	16 (26.2%)	15 (24.6%)	18 (29.5%)	8 (13.1%)	4 (6.6%)	2.49 ± 1.21		
Total	109 (14.9%)	80 (10.9%)	236 (32.2%)	229 (31.3%)	78 (10.7%)	3.12 ± 1.20		

Table 4. Familiarity with the technique and skills on how to address complications associated with TADs.

Complication	1 = Strongly disagree N (%)	2 = Disagree N (%)	3 = Neutral N(%)	4 = Agree N (%)	5 = Strongly agree N (%)	Average	P Value
Root contact -before	13 (21.3%)	10 (16.4%)	17 (27.9%)	18 (29.5%)	3 (4.9%)	2.80 ± 1.22	0.000
Root contact -after	0 (0%)	0 (0%)	7 (11.5%)	42 (68.9%)	12 (19.7%)	4.08 ± 0.56	
Mini-implant fractures -before	14 (23.0%)	12 (19.7%)	20 (32.8%)	13 (21.3%)	2 (3.3%)	2.62 ± 1.16	0.000
Mini-implant fractures -after	0 (0%)	0 (0%)	9 (14.8%)	43 (70.5%)	9 (14.8%)	4.00 ± 0.55	
Soft tissue inflammation-before	8 (13.1%)	13 (21.3%)	17 (27.9%)	18 (29.5%)	5 (8.2%)	2.98 ± 1.18	0.000
Soft tissue inflammation-after	0 (0%)	0 (0%)	7 (11.5%)	42 (68.9%)	12 (19.7%)	4.08 ± 0.56	
Mini-implant loosening -before	10 (16.4%)	12 (19.7%)	15 (24.6%)	18 (29.5%)	6 (9.8%)	2.97 ± 1.25	0.000
Mini-implant loosening -after	0 (0%)	0(0%)	8 (13.1%)	41 (67.2%)	12 (19.7%)	4.07 ± 0.57	
Total-before	45 (18.4%)	47(19.3%)	69 (28.3%)	67 (27.5%)	16 (6.6%)	2.84 ± 1.20	0.000
Total-after	0(0%)	0(0%)	31 (12.7%)	168 (68.9%)	45 (18.4%)	4.06 ± 0.56	

Table 5. Willingness to learn the technique and skill on how to address complications associated with miniscrews.

Complication	1 = Strongly unnecessary N (%)	2 = Unnecessary N (%)	3 = Neutral N (%)	4 = Necessary N (%)	5 = Strongly necessary N (%)	Average	F	P Value
Root contact	0 (0%)	0 (0%)	3 (4.9%)	15 (24.6%)	43 (70.5%)	4.66± 0.57	0.154	0.92
Mini-implant fractures	0 (0%)	0 (0%)	2 (3.3%)	15 (24.6%)	44 (72.1%)	4.69± 0.53		
Soft tissue inflammation	0 (0%)	0 (0%)	2 (3.3%)	15 (24.6%)	44 (72.1%)	4.69± 0.53		
Mini-implant loosening	0 (0%)	0 (0%)	1 (1.6%)	15 (24.6%)	45 (73.8%)	4.72± 0.49		
Total	0 (0%)	0 (0%)	8 (3.3%)	60 (24.6%)	176 (72.1%)	4.69± 0.53		

Figures

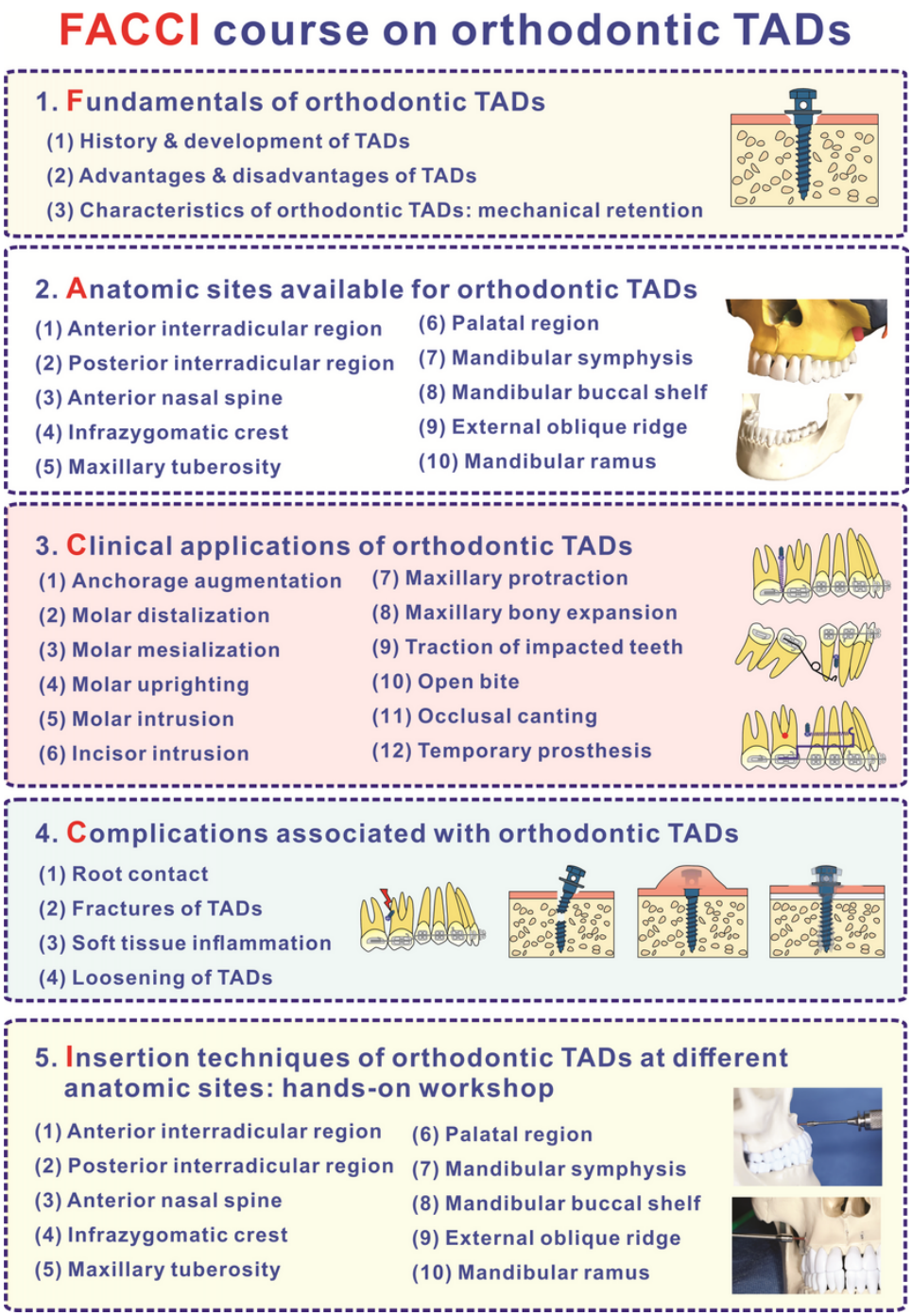

Figure 1

The curriculum on orthodontic TADs. The content of the curriculum includes five modules. (1) The first module is to introduce the fundamentals of orthodontic temporary anchorage devices (TADs), including history and development of TADs, advantages and disadvantages of TADs and characteristic of orthodontic TADs. (2) The second module is mainly about how to insert TADs in different anatomical sites. These anatomical sites are suitable and safe, and are used in clinical practice. (3) The third module is to explain how TADs play a role in different types of tooth movement to make the teeth reach the position the doctor wants. (4) The fourth module includes 4 common complications after insertion of TADs and how to deal with these problems. (5) Finally, the teachers and assistants used tooth models and

tools to teach students to practice implant TADs in different parts of the oral cavity, and pointed out the problem during the operation.

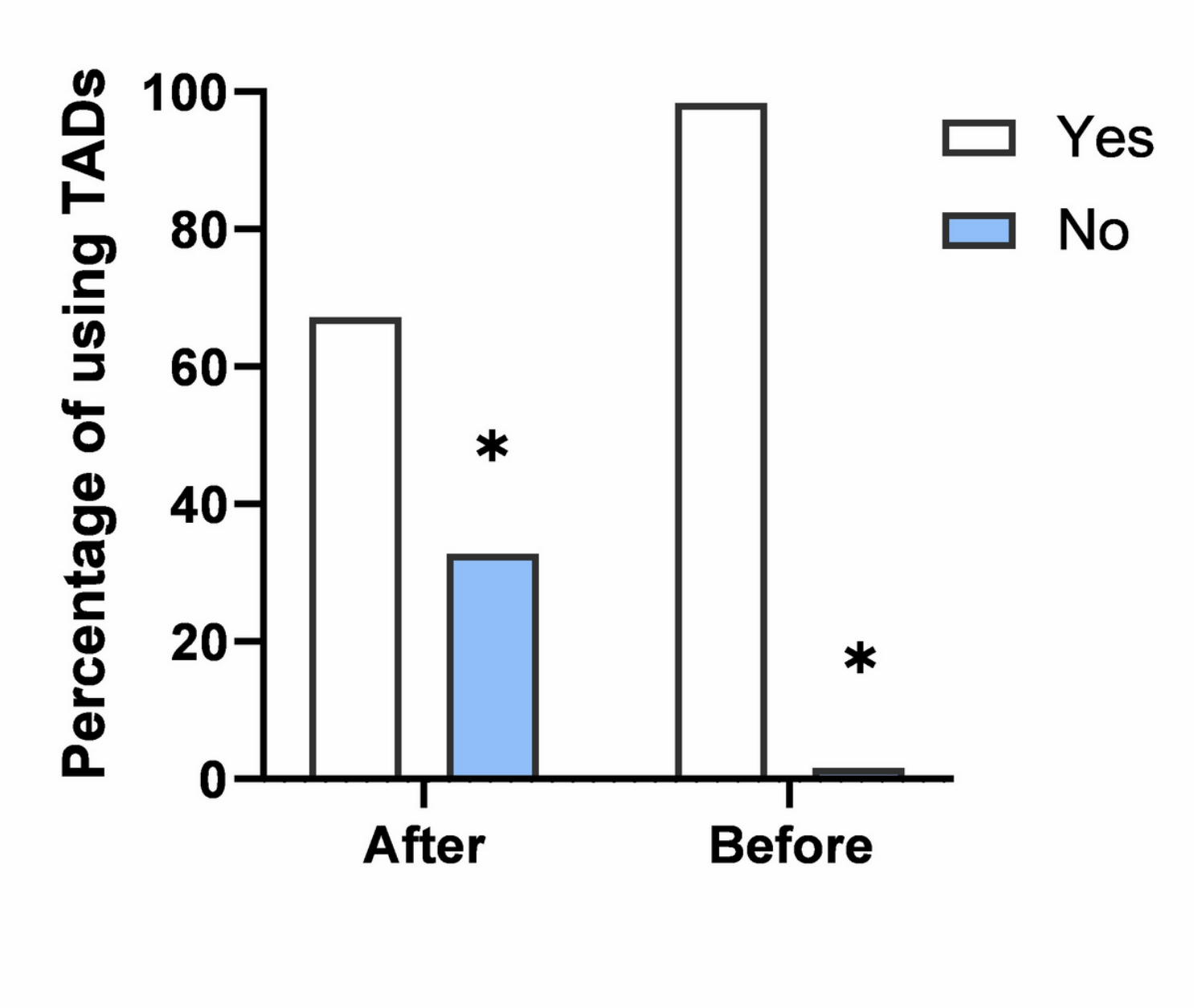

Figure 2

Percentage of using TADs in clinic before and after the course. In the questionnaire, participants were asked whether to use TADs. The bar graph shows the result of the change in the ratio of use of TADs before and after course (*p□0.001 significant difference). After class, more participants chose to use TADs in the clinic.

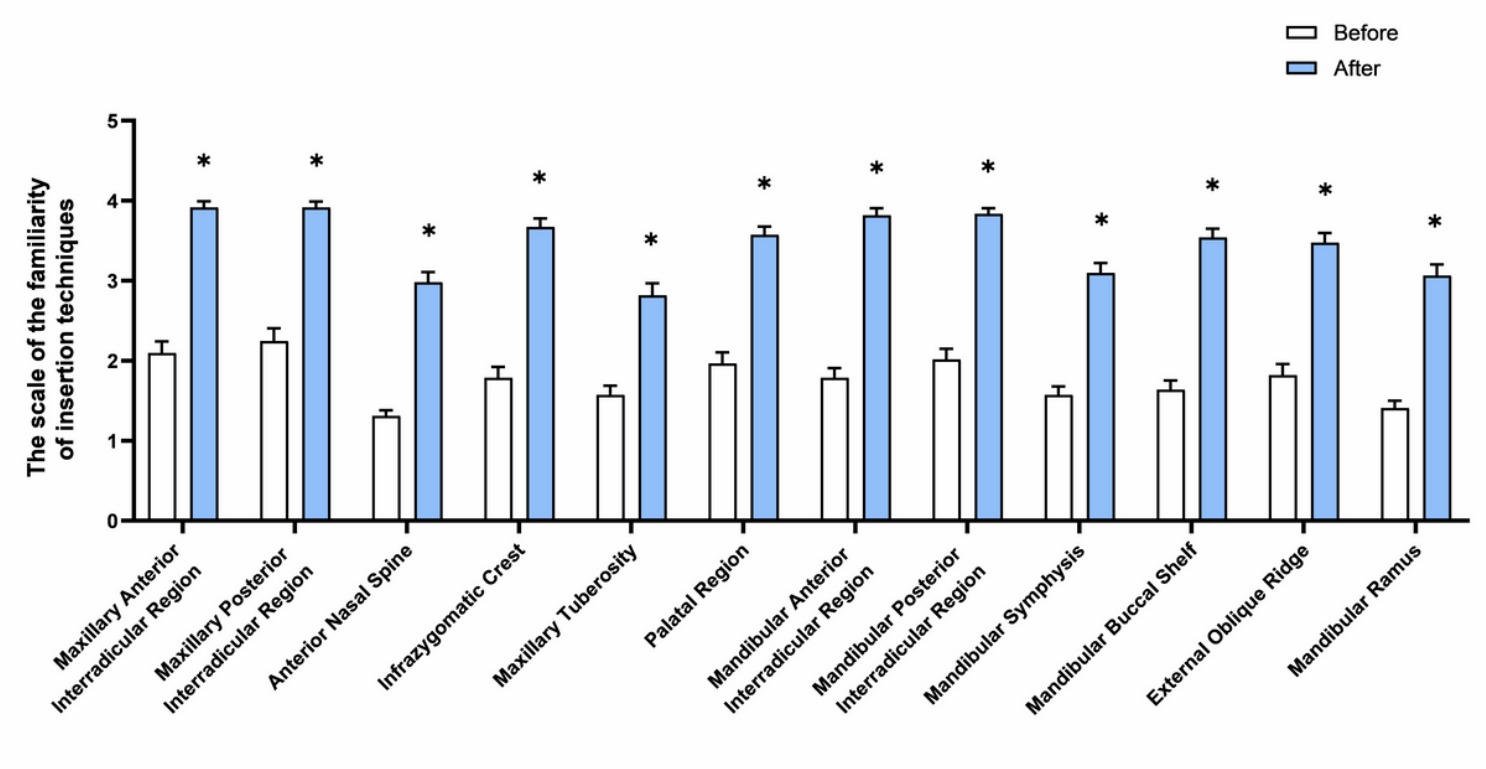

Figure 3

The scale of the familiarity of insertion techniques. The bar graph shows the statistical difference of participants' familiarity of inserting anchorages at different anatomical sites before and after course (*p□0.001=significant difference). Participants' familiarity of relevant knowledge had improved significantly after the class.

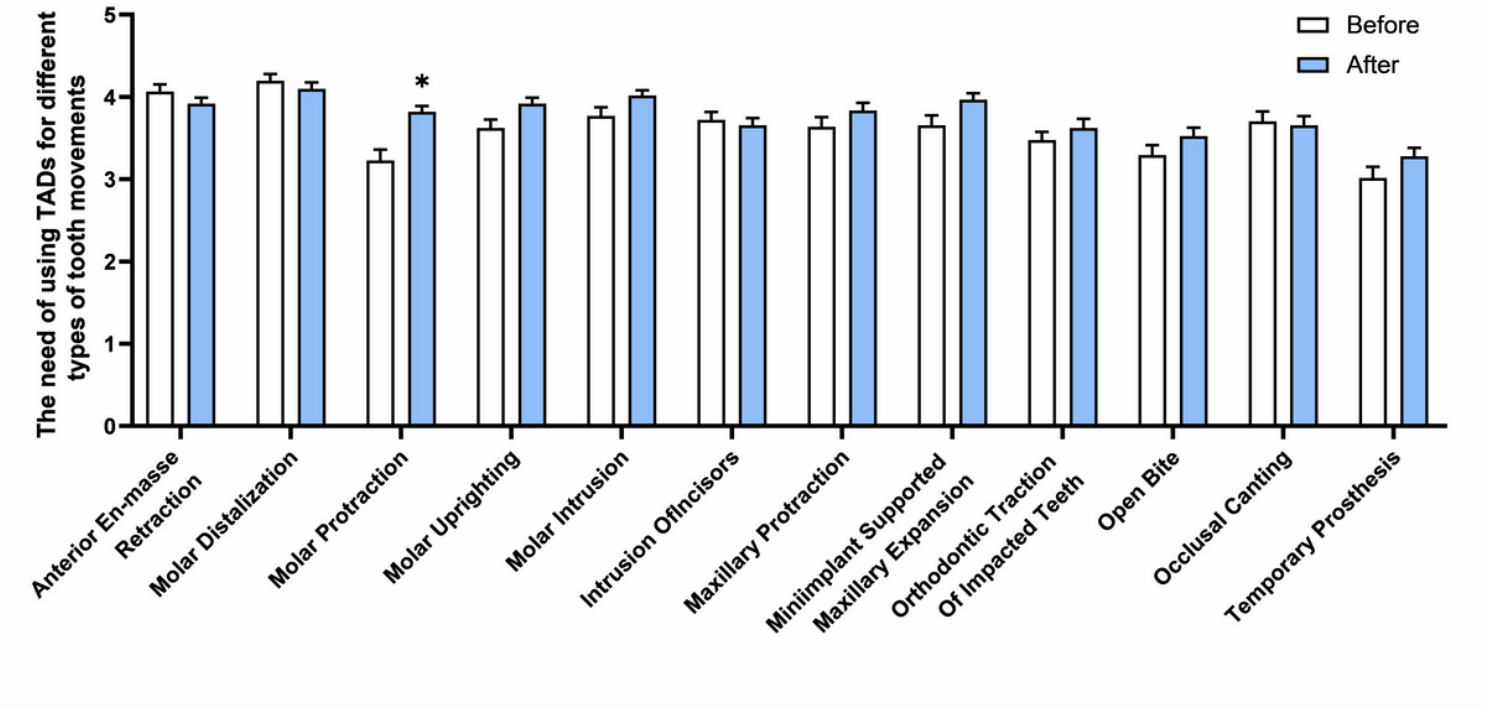

Figure 4

The need of using TADs for different types of tooth movements. Participants were asked whether TADs are needed for different types of tooth movement. The graph shows the statistical results of the participants' answers. Among them, only the results of malor protraction are statistically different (*p□0.001=significant difference).