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Original Article

Factors associated with usage frequency and pricing of temporary anchorage devices among orthodontists

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Abstract *Background/purpose:* Temporary anchorage devices (TADs) are widely used in contemporary orthodontic treatments for anchorage purposes. This research aimed to investigate orthodontists' attitude toward temporary anchorage devices (TADs) by surveying their TAD usage frequency and pricing and to identify factors influencing TAD usage frequency and pricing.
Materials and methods: A structured, self-administered questionnaire with a total of 26 questions was randomly distributed to members of the Taiwanese Association of Orthodontics at the annual orthodontic meeting. The questionnaire comprised 6 questions on demographics, 10 questions on work patterns and patient type, and 10 questions on orthodontic technique. Responses were analyzed using a Pearson chi-Square test to identify factors of interest.
Results: Factors associated with TAD usage frequency included degree of income satisfaction, number of working hours per week, and proportion of extraction-based treatments in treatment plans. Factors associated with TAD pricing included orthodontist age, geographic region of practice, and adult treatment fee.
Conclusion: More Taiwanese orthodontists use TADs compared with orthodontists in other countries. TADs have become universally accepted, but practitioners use them selectively. The main factor influencing TAD usage frequency was the proportion of extraction-based treatments in treatment plans, and those influencing TAD were orthodontist age, geographic region of practice, and adult treatment fee. These findings may be applicable to other parts of the world and should be investigated at an international level.

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Introduction

Orthodontic anchorage is a critical aspect of successful orthodontic treatment.[1] Because skeletal anchorage can avoid undesirable tooth movements, it has largely replaced conventional anchorage options and broadened the scope of nonsurgical orthodontic treatments.[2] As the most recent breakthrough in orthodontics,[3] skeletal anchorage have improved considerably since their introduction in 1945 by Gainsforth and Higley,[4] who suggested using implants as anchor device. In the following decades, pioneers conducted animal experiments with different materials and designs trying to find an appropriate and practical way clinically regarding skeletal anchorage. It was not until Kanomi's report in 1997 that modern temporary anchorage devices (TADs) were conceptualized.[5] He first introduced temporarily-placed miniscrews and stimulated their rise in popularity.

Extra-oral appliances such as headgear and face masks or tooth-borne devices such as the transpalatal arch (TPA) were conventionally used as anchorage devices.[6] Nonetheless, such devices have limitations in anchorage control.[7] To overcome such limitations, biocompatible intraosseous titanium miniscrew implants were introduced in the early 21st century.[8] Such miniscrew implants are quick and easy to insert, minimally invasive, and versatile. Consequently, they have been incorporated in orthodontic practice.[9] Moreover, miniscrew anchorages have facilitated successful corrections to skeletal discrepancies that previously required surgery.[10] These anchorages can help improve patients' compliance and can provide a reliable support for tooth movements in all directions. However, clinical use of miniscrew anchorages also poses risks related to screw failure and structural damage, which may make practitioners hesitant to use them.[11]

According to the literature, by 2016, the United States had the highest percentage of orthodontists using TADs (91%),[12] followed by Switzerland (80%),[13] France (66%),[14] and South Africa (61%).[15] Conversely, India had the lowest percentage of orthodontists using TADs (43.7%).[16] However, the percentage of TADs usage has been poorly defined in some studies, and such numbers may not reflect the actual usage. TADs were often not used owing to fears of complications, cost concerns, lack of adequate skills, and patient nonacceptance.[15] In general, each TAD costs approximately US$300—US$600 in the United States[17] and US$450—US$650 in Australia.[18]

According to the preceding discussion, a gap exists between evidence-based knowledge of TADs and the use of such knowledge in practice.[19] Extant studies have focused primarily on the clinical success of TADs and their applications. By contrast, the present study explored orthodontists' attitude toward the acceptance of TADs by surveying how frequently they use miniscrew implants and how much they charge for them. Furthermore, we identified factors associated with TAD usage frequency and charge for future clinical reference.

Materials and methods

Questionnaire

The study was approved by the Taipei Medical University—Joint Institutional Review Board (N201803025). A structured, self-administered questionnaire was developed, reviewed by a panel of three experts, and then pretested by several orthodontists. These three experts were all orthodontic specialists certified by Ministry of Health and Welfare in Taiwan, who had practiced in orthodontic field over 10 years. The content validity of each item was measured by calculating its item-level content validity index (I-CVI) score. For every single question, experts could rate 1, 2, 3 and 4 which stands for very inappropriate, inappropriate, appropriate, and very appropriate subsequently. The relevance rating was recoded as 1 (rate 3 or 4) or 0 (rate 1 or 2). I-CVI score was calculated as the sum of relevance rating divided by the number of experts.

The questionnaire was anonymous and contained a total of 26 questions. The questions were devised to collect information regarding the respondents' demographics (6 items), work patterns and type of patients examined (10 items), and orthodontic techniques used (10 items).

Inclusion and exclusion criteria

Printed copies of the questionnaire were distributed to all the members of the Taiwanese Association of Orthodontics (TAO) attending the 2018 annual orthodontic meeting. The TAO members at the meeting comprised specialist members, associated members, and student members. The student members and associated members were excluded from this study. The questionnaire responses were collected at the reception desk before the closing ceremony.

Statistical analysis

The questionnaire responses were organized into tables to determine the frequency distribution (%). A goodness-of-fit test was conducted to assess the association between the demographic characteristics of the respondents and the characteristics of the orthodontic association. Descriptive statistics were computed using Excel 2015. The Pearson chi-square test was performed to determine whether significant associations existed between each survey item and TAD pricing (survey item 15) or usage frequency (survey item 24). Significance was set at $P \leq 0.05$. Moreover, the

relationships between highly correlated variables were further analyzed through a multiple-regression analysis.

Results

The questionnaire demonstrated moderate to high content validity, with the I-CVI scores ranging from 0.67 to 1.00. A total of 177 questionnaires were returned, yielding a response rate of 31.6%. The responses to the questionnaire items are listed in Tables 1–3 in the form of relative percentages. The chi-square goodness-of-fit test revealed that the respondents were representative of the orthodontic association in terms of gender and geographic region of practice but not in terms of age.

Respondent demographics

Most of the respondents (92.6%) were aged 30–60 years, of whom approximately half (51.1%) were aged 31–40 years.

Table 1 Demographics of questionnaire respondents.

S/N	Respondents	%
Sex:		
	Male	46.6
	Female	53.4
Age (Year):		
	≤30	2.3
	31–40	51.1
	41–50	19.3
	51–60	22.2
	61–70	5.1
	≥71	0
Years of orthodontic practice:		
	≤5	22.3
	6–10	19.4
	11–15	17.7
	16–20	12.6
	21–25	15.4
	≥26	12.6
Geographic region of practice in Taiwan:		
	Northern	49.4
	Northwestern	5.7
	Midwestern	14.8
	Southwestern	11.9
	Southern	17.6
	Eastern	0.6
Degree of income satisfaction:		
	Very unsatisfied	2.8
	Unsatisfied	9.1
	Normal	59.7
	Satisfied	25.6
	Very satisfied	2.8
Highest level of education:		
	College of dentistry	45.5
	Master's degree	48.9
	PhD degree	5.7

Moreover, approximately half (49.4%) of the respondents practiced in northern Taiwan, possibly in the Greater Taipei Area. Nearly 89.1% of the respondents were satisfied with their income. Approximately half of the respondents earned a master's degree or higher during their orthodontic training (54.6%), and the remaining received only clinical orthodontic training without a degree. Therefore, the respondents were representative of the orthodontist association, which predominantly comprises young to middle-aged working adults who are active orthodontists. Additionally, the respondents practicing in northern Taiwan (49.4%) were determined to have relatively easy access to new technology.

Respondents' work patterns and case types

Table 2 presents the respondents' work patterns and case types. Because dentists generally work 8-h days, most of the respondents (81.1%) reported working more than 4–5 days (32–40 h) per week. In most of the dental offices, more than half of the orthodontic patients were adults (74.7%), with most of them having I and class II malocclusions and relatively few having class II malocclusions. Furthermore, most of the respondents charged adult orthodontic patients NT$100,000–NT$150,000 (US$3500–US$5000) (79.4%) for treatment, and none of them charged more than NT$200,000 (US$7000). We also noted three pricing options regarding fees set for TADs in Taiwan: NT$5000 (US$180) per piece, NT$10,000NT (US$360) per piece, and no additional charge to the orthodontic treatment cost. We observed an even distribution in the proportion of respondents charging the three aforementioned pricing options.

In Taiwan, access to continuing education is convenient, and orthodontists are encouraged to learn about the most up-to-date technology and clinical knowledge. As presented in Table 2, approximately 50% of the respondents reported spending more than 10 days annually on continuing education, which is sufficient to fulfill their licensure requirements.

Respondents' orthodontic techniques utilized

Table 3 presents the respondents' choices of orthodontic techniques. Among the respondents, approximately 77% reported seldom or never using headgear (Table 3), which is a type of conventional anchorage device. Our respondents reported seldom using edgewise standard brackets, clear aligners, or lingual orthodontics. Regarding space closure devices, the respondents appeared to favor sliding mechanisms over loop mechanisms. Approximately 94.2% of the respondents reported applying extraction-based treatment techniques to more than half of their patients. Furthermore, nearly 92% of the respondents reported using TADs, with approximately half of them (47.1%) reporting the administration of TADs to more than half of their patients.

Factors affecting TAD pricing and usage frequency

The chi-square test revealed that several factors were highly correlated with TAD pricing, including orthodontist

Table 2 Respondent work patterns and case types.

S/N	Respondents	%	S/N	Respondents	%
Working hours per week:			Percentage of Class II cases:		
	≤12	4.0		0–25%	14.0
	16–24	14.9		25–50%	41.9
	28–36	37.4		51–75%	18.0
	40–48	35.1		76–100%	1.7
	≥52	8.6		Not calculated	24.4
Number of orthodontic patients treated per day:			Percentage of Class III cases:		
	≤5	27.0		0–25%	43.9
	5–10	27.0		25–50%	27.2
	10–20	23.6		51–75%	5.2
	>20	13.8		76–100%	0.6
	Not calculated	8.6		Not calculated	23.1
Percentage of child cases:			Adult treatment fee (US$):		
	0–25%	55.2		Under 3500	12.4
	25–50%	29.3		3500–5000	79.4
	51–75%	8.0		5000–7000	8.2
	76–100%	2.3		Above 7000	0
	Not calculated	5.2			
Percentage of adult cases:			TADs charge (US$):		
	0–25%	5.7		Included in total fee	31.0
	25–50%	3.8		Under 170	32.7
	51–75%	40.2		170–340	35.7
	76–100%	34.5		Over 340	0.6
	Not calculated	4.0			
Percentage of Class I cases:			Days spent in continue education annually:		
	0–25%	24.9		Less than 1	1.2
	25–50%	39.3		1–3	7.0
	51–75%	13.9		4–6	27.5
	76–100%	1.2		7–9	14.0
	Not calculated	20.8		10 or more	50.3

Table 3 Respondents' orthodontic techniques used (percentage).

Survey Question	Never 0%	Seldom 25%	Sometimes 50%	Often 75%	Always 100%
Headgear	19.3	57.9	28.8	2.9	0
Edgewise standard bracket	42.1	24.0	12.3	11.1	11.1
Clear aligner	42.4	43.6	9.9	2.3	1.7
Lingual orthodontic	81.4	14.5	2.3	1.7	0
Loop mechanism	12.8	45.3	27.9	12.2	1.7
Sliding mechanism	0.6	8.2	10.5	59.6	21.1
Extraction treatment plan	1.2	4.7	41.9	51.7	0.6
TADs usage	8.1	44.8	32.0	14.5	0.6
Surgical-orthodontics	14.0	56.4	25.0	4.7	0
CAD-CAM digital orthodontics	73.1	18.1	4.7	3.5	0.6

Abbreviations: CAD-CAM: computer-aided design and computer-aided manufacturing; TADs: temporary anchorage devices.

age, geographic region of practice, adult treatment fee, and annual continuing education hours. Factors significantly associated with TAD usage frequency included the degree of income satisfaction, number of working hours per week, and proportion of extraction-based treatments in treatment plans (Table 4).

Table 4 Survey items significantly associated with TADs usage frequency and pricing.

Variables associated with TADs charge	*P* value*
Age	0.042
Geographic region of practice	0.008
Adult treatment fee	0.005
Annual continuing education hours	0.023
Variables associated with TADs usage frequency	***P* value***
Degree of income satisfaction	<0.001
Working hours per week	0.02
Extraction treatment plan	0.001

*Chi-square test.
Abbreviations: TADs: temporary anchorage devices.

Factors influencing TAD pricing and usage frequency and their associations

Among the aforementioned factors associated with TAD pricing, adult treatment fee had the most positive association with TAD pricing, followed by geographic region of practice and orthodontist age (Table 5). Notably, we observed a negative association between annual accumulated continuing education hours and TAD pricing; this finding signifies that orthodontists devoting more hours to continuing education per year charge less for TADs (see Table 6).

Among the aforementioned factors associated with TAD usage frequency, proportion of extraction-based treatments in treatment plans had the strongest association with TAD usage frequency, followed by number of working hours per week and degree of income satisfaction. Degree of income satisfaction had a negative association with TAD usage frequency, indicating that practitioners with greater satisfaction with their income have a lower frequency of TAD usage.

Table 5 Variables significantly associated with TADs pricing.

Variable	Reg. Coefficient	*P* value*
Age	0.0519	0.042
Geographic region of practice	0.1078	0.008
Adult treatment fee	0.2897	0.005
Annual continuing education hours	−0.035	0.023

*Multiple regression.
Abbreviations: TADs: temporary anchorage devices.

Table 6 Variables significantly associated with TADs usage frequency.

Variable	Reg. Coefficient	*P* value*
Degree of income satisfaction	−0.0071	<0.001
Working hours per week	0.044	0.02
Proportion of extraction-based treatments in treatment plans	0.564	0.001

*Multiple regression.
Abbreviations: TADs: temporary anchorage devices.

Discussion

In our study, 92% of the respondents reported using TADs, which is considered very high and is comparable to the usage rate among American orthodontists in 2010 (91%). However, in the American study, the 91% who reported using TADs included those who used at least one TAD, with only 14% of them using 20 TADs.

Although TADs are universally accepted, clinicians use them selectively. In our study, 44.8% of the respondents reported seldom using TADs. However, a Swiss study revealed that 72.9% of participants reported using TADs in less than 10% of their patients.[20] In our study, 47.1% of the respondents reported using TADs in more than half of their patients, as opposed to 1.6% of the Swiss respondents. An international survey study conducted by APOS in 2020 indicated that TADs were less popular in the United States and Canada than in Asian countries.[21] By 2020, only 65.8% of Canadian orthodontists reported using TADs.[22] Thus, TAD usage is decreasing in countries across Europe and North America. Practitioners may be more case-selective when using TADs. Moreover, white populations may have more harmonious maxillofacial structures with longer and wider dentition compared with those of Asian populations, which is also reflected in the high nonextraction rate in Europe and North America. Thus, the factors identified in this study may provide insight into the differences in TAD usage among various countries.

Our findings also reveal that geographic region of practice influenced TAD pricing. Specifically, most of our respondents worked in northern Taiwan (49.4%), followed by southern Taiwan and midwestern Taiwan (Table 1). These three regions contain the three largest metropolitan areas in Taiwan. Compared with orthodontists in rural areas, those in urban areas likely charge more for treatments such as TADs owing to the higher overhead expenses in cities. An investigation in 1991 on dental fees revealed that fees tend to be higher in metropolitan areas than in small cities and that fees tend to be higher in small cities than in rural areas.[23]

Age was also found to be a major factor influencing TAD pricing. Most of our respondents were in their thirties, which, according to the goodness-of-fit test, was not representative of the study population. However, our results indicate that older orthodontists tend to charge higher treatment fees. As an orthodontist ages, their accumulated orthodontic knowledge, experience, and professional reputation increase. Senior orthodontists are perceived as more experienced and knowledgeable and may therefore raise their fees. In such cases, the treatment fee is intended to reflect the service provided, which explains why orthodontist age influences TAD pricing.

We also noted annual continuing education hours to be negatively but weakly ($\beta = 0.033$) associated with TAD pricing. Several previous studies have revealed that the most common reason for not using TADs was inadequate training or a lack of knowledge. According to our study, more than 50% of the respondents reported spending more

than 10 days per year attending lectures or hands-on classes, which exceeds the minimum days required for licensure renewal. As orthodontists become more competent, they may believe that TADs can improve treatment efficiency and subsequently lower cost to encourage patients to receive TADs.

TADs are primarily used to prepare the anchorage for incisor retractions to close the extraction space.[24] In orthodontic patients for whom extraction-based treatments are planned, anchorage preparation is critical for positive clinical outcomes. A study evaluating TPA effectiveness suggested that the TPA alone is insufficient among patients who require anchorages.[25] TADs can offer absolute support and avoid dental side effects from tooth movement. Therefore, orthodontists administering more extraction-based treatments tend to have a higher TAD usage frequency.

Responses to items on work patterns could be used to identify orthodontists' attitudes toward their work. According to several studies, orthodontists with a positive experience with TADs often believe that TADs add value to their clinical practice.[26] Orthodontists who spend more time working should be enthusiastic about providing better care to their patients. However, we observed a comparatively weak association ($\beta = 0.044$) between the number of working hours and TAD usage frequency. Hence, whether the number of working hours is related to TAD usage frequency is unclear. Moreover, the association between TAD usage frequency and degree of income satisfaction was weak ($\beta = -0.0071$).

Our questionnaire has several areas for improvement. Because the research topic has garnered little attention, relevant data are not widely available. Moreover, little information regarding TAD pricing has been reported in other countries, possibly owing to competition between clinics. Hence, designing the questionnaire to incorporate variables used in similar questionnaires, such as those used in the American study, could provide more comparable findings for analysis. Moreover, the questions could be improved to enhance their specificity. For example, the options for the items on TAD usage frequency could be expanded to collect information on the number of TADs used per month rather than the overall percentage of TADs used. Finally, our survey was based on recollection rather than chart reviews; thus, the reliability of the results may be a concern.

A limitation of our study is that the survey was only distributed to members of the Taiwanese Association of Orthodontics. This may limit the sample's representativeness and the generalizability and applicability of the findings. Another limitation is that the sample is not adequately representative of all Taiwanese orthodontists. Although the questionnaire was randomly distributed, the respondents were predominantly young with relatively few years of practice. Additionally, more than half (55%) of the respondents resided in northern Taiwan, where the conference was held. This limitation can be addressed by sending out follow-up online surveys to all TAO specialist orthodontists.

This study provides a basis for future research on TADs. International and longitudinal studies should be conducted to identify trends in orthodontic treatments among various countries and determine whether the identified factors remain relevant over the next decade.

In conclusion, our results reveal that 92% of our respondents reported using TADs, a higher percentage than those reported in studies conducted in other countries; 47.1% of our respondents reported using TADs in more than 50% of their patients, and 44.8% reported seldom using TADs. Taiwan provides three pricing options for TADs: NT$5000, NT$10,000, and no additional cost. Our findings reveal an even distribution in the proportion of orthodontists charging the three aforementioned pricing options. Factors positively associated with TAD pricing included orthodontist age, geographic region of practice, and adult treatment fee. Annual continuing education hours had a negative but weak association with TAD pricing. The main factor affecting TAD usage frequency was proportion of extraction-based treatments in treatment plans. We noted working hours per week to be weakly associated with TAD pricing and usage frequency. Degree of income satisfaction also demonstrated a negative yet negligible association with TAD usage frequency.

Declaration of competing interest

The authors have no conflicts of interest relevant to this article.

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