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ABSTRACT

Title of Thesis: Global Temporary Anchorage Device (TAD) Usage: A Survey of Orthodontists

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Objective: We aim to determine how often TADs are used worldwide and establish guidelines for implementing TADs in everyday practice.

Methods: A 19 question survey was sent to orthodontists around the world asking opinion based, case-specific, and placement technique questions regarding TADs. The country of practice and length of time practicing orthodontics were the independent variables.

Results: Most orthodontists use TADs rarely/sporadically. There were significant findings for how TADs are being used, sizes, and placement techniques amongst different continents. There was a significant difference in how many TADs orthodontists placed in residency according to how long they have been practicing, but it did not greatly affect frequency of use, mechanics, or placement technique.

Conclusion: The frequency of TAD use is similar worldwide and amongst different age groups. Although significant data was found in this study, there is such variability in regard to TADs that clear guidelines were not established.

Global Temporary Anchorage Device (TAD) Usage: A Survey of Orthodontists

by
Kelsea Ashton

Thesis submitted to the Faculty of the Graduate School of the
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I Introduction

I.1 Literature review

A temporary anchorage device, or TAD, is an adjunctive appliance placed specifically to provide orthodontic anchorage and is removed after biomechanical forces are applied.¹ TADs can be further categorized by their key characteristic, either a “screw” or a “plate”.² Terms used in the literature or by international lecturers to reference TADs include mini-implants, miniscrews, micro-implants, miniplates, onplates, miniplate anchor screws and many more.¹ Although there is no general consensus on terminology, “mini-implant” is the most frequently used term in the orthodontic literature.³ TADs are becoming more common in modern orthodontics because they eliminate the need for patient compliance, thus producing better results in higher anchorage requirement cases.

Anchorage was first described in 1923 as “the base against which orthodontic force or reaction of orthodontic force is applied”, and in 2000 as “resistance to unwanted tooth movement”.^{4, 5} Three types of anchorage are typically available in orthodontics: minimum, moderate, and maximum. Minimum anchorage is when the majority of space is closed by protraction of the posterior teeth, moderate anchorage entails reciprocal space closure of the anterior and posterior teeth segment, and maximum anchorage means that most space closure occurs by retraction of the anterior teeth.⁶ The higher the anchorage requirement is in a case, the more patient compliance is needed. For years orthodontists have been using headgear, a Nance button, or even a transpalatal arch (TPA) for cases requiring maximum anchorage. However, even while utilizing maximum anchorage appliances, it has been estimated that as much as 35% of space is lost due to mesial movement of the posterior teeth in maxillary first bicuspid extraction cases, and 1/3 of space closure occurs from anchorage loss in all first bicuspid extractions. This number

is even higher for second bicuspid extractions, estimating that 1/2 of space closure occurs from anchorage loss.⁷ The unwanted anchorage loss often leads to undesirable changes in the occlusion. This has been the driving force to create methods to obtain absolute anchorage in orthodontics, where the anchor unit remains completely stationary as the forces applied to the teeth are dispersed to the surrounding skeletal structures. This described characteristic is why absolute anchorage can be interchanged with the term skeletal anchorage.⁶

Over 60 years ago, authors began trying to create absolute anchorage for orthodontics using devices such as Vitallium screws in dogs,⁸ endosseous blade implants for anterior teeth retraction,⁹ and titanium osteosynthesis screws for maxillary incisor intrusion.¹⁰ Since the start of the twenty-first century, TADs have become increasingly popular and are usually made out of titanium or a titanium alloy. This material ensures biocompatibility to prevent any inflammatory response, discharge of corrosive by-products into the surrounding tissue and bone, or necrosis.¹¹ Their sizes ranges from 4-20mm in length and 1-2.3mm in diameter.¹² TADs mostly rely on mechanical retention and do not always osseointegrate like dental implants.³ TADs are placed in both maxillary and mandibular alveolar bone and are only left in the mouth until their intended function is completed, after which, they are removed. Most mandibular TADs are positioned in inter-radicular bone, as well as the area of the mandibular symphysis, anterior external oblique ridge, and retromolar area of the alveolar crest. Maxillary TADs are generally placed in alveolar bone, but a popular extra-alveolar site is the palate. Other extra-alveolar sites in the maxilla include the infrazygomatic ridge, incisive fossa, and canine fossa.¹³

Site selection is critical in the overall success of the proposed orthodontic treatment with TADs. Five important parameters have been described to determine an adequate site for TAD placement.⁶ The first parameter includes TAD indication, system used, and required mechanics.

The mechanics should be as “simple and fail-safe” as possible, and the TAD should not be placed in the way of future tooth movement. The second parameter is placement in the attached gingiva, clear of the frenulum, which will prevent tissue overgrowth and help with patient comfort, preventing micro-movement that can lead to failure. The third parameter is sufficient interradicular space that is not obstructed by root proximity. The fourth parameter is to avoid anatomical structures such as the inferior alveolar nerve. The fifth and final parameter is to place in areas of adequate cortical bone thickness, since it ensures better primary stability and success.¹⁴

The placement technique of TADs can differ depending on the system used, based on that, consulting with the manufacturer before insertion is always recommended.⁶ The use of topical vs. local anesthesia during placement is debated amongst professionals. During TAD placement, the device will penetrate four different anatomical levels. The first and second anatomical layers, the gingival tissue and the periosteum respectively, are highly innervated. However, topical anesthetic effectively desensitizes the neural input from the gingiva and is highly effective in reducing painful stimuli originating from the periosteum if enough time is given by the administer to allow for diffusion across the periosteal layer. The third layer, the cortical plate, and the fourth layer, the cancellous bone of the jaw, are not highly innervated and do not require anesthetic.⁶

It is recommended that topical anesthetic be applied to dry mucosa for 2-3 minutes. Peak anesthesia is reached in 5-10 minutes and lasts for 25-30 minutes.¹⁴ The main argument for solely using topical anesthetic, besides avoiding an injection, is that the patient can alert the clinician if they are close to sensitive structures such as the root of a tooth or the maxillary sinus. Therefore, the clinician will not penetrate these areas, which could cause irreversible damage.⁶ One study showed that 20% topical benzocaine and a combination of topical lidocaine, tetracaine and phenylephrine is adequate for pain management during TAD placement, however, the combination

topical was found to be more effective overall.¹⁵ Those in favor of local anesthetic use argue that the operator will feel a change in resistance if he/she hits a sensitive structure and there is no need for the patient to alert the doctor.¹³ Local anesthetics have been found to provide more predictability while managing patient discomfort during TAD placement than compounded topical anesthetics.¹⁶

Self-tapping and self-drilling are the two main TAD designs.¹⁷ The self-tapping screw has a threaded body and tapered furrow at the tip that cuts a thread into the bone, eliminating the need for a surgical tap. They often require pilot holes, especially in dense cortical bone or coarse trabecular bone areas because of their non-cutting tip.¹⁴ Because a pilot hole is a prerequisite to self-tapping TADs, drill-bit breakage, over drilling, and thermal necrosis of bone are risks associated with this technique and are more time consuming.¹⁷ The self-tapping method is usually considered more invasive due to the pilot hole, but once the pilot hole is drilled, the implant placement is easy with minimal tissue damage and deviation from ideal placement is not possible because the pilot hole guides the screw.⁶

The second design, the self-drilling implant, has a sharp tip and threaded body, similar to a corkscrew, and does not require a pilot-hole.¹⁴ Therefore, insertion is simpler and requires the use of fewer instruments while producing little bone debris, less thermal damage, and minimal patient discomfort due to no pre-drilling.^{17, 18} On the other hand, high pressure may be necessary with self-drilling insertion, which can lead to patient discomfort, resorption, and subsequent failure.⁶ This high pressure can also cause a loss of tactile sensitivity to the practitioner leading them to deviate from the ideal placement path.

Self-drilling and self-tapping screws are effective anchorage units for en-masse retraction of anterior teeth.¹⁹ Therefore, the self-drilling method is preferred over the self-tapping method in

places of equal stability due to the clinical advantages.¹⁸ Self-drilling screws are not recommended in areas of dense and thick cortical bone such as the mandibular molar region because of the resistance in these areas during placement.⁶ Self-tapping screws would be preferred in this area to prevent screw or bone fracture.¹⁸ Self-drilling systems also have greater primary stability, which is defined as the absence of mobility in the bone bed after TAD placement and is dependent on the mechanical engagement of the TAD within the bone socket.^{20, 21} Progressive mobility of a TAD can occur if there is a lack of initial stability, which can lead to TAD failure.²¹

Primary stability is one of the most important factors when using TADs since they do not require osseointegration. Factors that have been associated with primary stability include insertion site, root proximity, TAD design, placement technique, and loading time of orthodontic force. However, cortical bone density is thought to be one of the most critical factors.²² Areas of favorable bone ensure good primary stability and, therefore, a better chance of long-term success.⁶ Primary stability can also be affected by maximum insertion torque value. One study showed that 5 to 10 Ncm of insertion torque gave the best results in terms of resistance to movement compared to TADs placed at less than 5 Ncm,²³ while other studies recommended a torque force of 15 to 20 Ncm.²⁴ A maximum placement torque over 10 Ncm could overheat the bone and result in TAD failure.²⁵

Placement angle is also an important factor for temporary anchorage device success. Some authors believe that TADs should be inserted at a 90-degree angle (perpendicular) to the cortical plate, whereas others believe insertion at an oblique angle will increase the surface area of thread to cortical bone contact, therefore increasing primary stability.¹³ Immediate loading of TADs is another controversial topic. A systematic review of the literature found both successes and failures with immediate loading.³ However, it was difficult to compare studies because the term

“immediate loading” varied amongst practitioners from the day of placement to 4 weeks post-placement. Overall, it is believed that the better the bone quality, the greater chance of success with immediate loading. However, studies from the systematic review also found that immediate loading in places with poor bone quality can promote better mechanical stability of the TAD.

TAD success rate ranges from 75% to 94%.²⁶⁻²⁸ These results are considered disappointing compared to the >90% success rate of dental implants.²⁹ Insertion site, insertion technique, proximity to adjacent roots, inflammation, smoking, and diabetes have all been associated failure risks. Additionally, failure risks tend to be higher in patients younger than 20-years-old due to their active bone metabolism and low bone maturation.²⁹

When it comes to the clinical application of TADs, they can successfully correct the antero-posterior and vertical dimensions, enable treatment where traditional orthodontic anchorage would be impossible, and even avoid orthognathic surgery in some patients.²⁹ With all the treatment possibilities, TADs are most commonly used for anterior retraction when premolars have been extracted or where anchorage concerns are significant in cases with generalized spacing.³⁰ TADs are an excellent option for bimaxillary protrusion cases where full retraction is needed to correct a poor profile or lip incompetence. Other corrections in the antero-posterior direction include protraction of posterior teeth when either a tooth has been extracted or tooth agenesis is present and a dental implant is not desired, molar distalization in Class II cases, and canine substitution cases where protraction of the posterior segment is needed.⁶

In the vertical dimension, TADs can be used to correct anterior open bites by the intrusion of the posterior maxillary teeth, controlling the vertical movement of the mandibular posterior teeth in high angle patients, or by a combination of the above.⁶ TADs can aid in intrusion of maxillary and mandibular incisors for deep bite correction and maxillary anterior intrusion for

excessive gingival display. Single tooth intrusion from missing an opposing counterpart can also be accomplished with TADs as well as molar uprighting and palatal expansion.¹³ In patients with mutilated dentitions, TADs can create desirable anchorage situations that were not previously possible for orthodontists and help utilize the osteogenic potential of orthodontic tooth movement to help recreate an alveolar ridge that has collapsed over time.⁶

I.2 Study aims

This investigation was conducted because TADs are used every day in orthodontics with various techniques, companies, and indications. However, there is a lack of universal consensus revolving around different issues related to TADs and their clinical application. Therefore, this comprehensive worldwide investigation was produced to determine the percent rates of TADs being used around the world and to potentially help establish guidelines for implementing TADs in everyday practice.

I.3 Research hypothesis

H.1: It is hypothesized that there will be a difference in TAD mechanics, placement techniques, and frequency of use amongst orthodontists from different countries. This could be due to their differing education, treatment philosophies, emphasis on particular literature, and even socioeconomic factors between the different countries.

H.2: The second hypothesis for this study is that orthodontists practicing for over 10 years will not use TADs as frequently as orthodontists who have been practicing for 10 years or less. An explanation for this could be the lack of clinical experience on placing TADs in residency or already having established mechanics for some of the main reasons TADs are used.

II Materials and methods

The IRB reviewed this survey study at the University of Maryland and was approved as exempt under the number HP-00088589.

II.1 Survey design

While developing this survey (Figure 1), certain questions were modified from previous surveys on temporary anchorage devices,^{30,31} while other questions were created explicitly for this study because they have not yet been addressed in prior research. Demographics, placement technique, types of TADs utilized, opinion-based questions, and case-specific questions were included in the questionnaire. Once the first draft of the questionnaire was developed, a pilot study was performed to validate the survey. Several orthodontic faculty members of different backgrounds and proficiencies from the University of Maryland were asked to critique the survey and provide feedback. After the faculty members' feedback were received, a statistician was consulted to evaluate the survey. Finally, the survey was submitted to the AAO Partners in Research (AAO-PIR) program for final review. The AAO-PIR performs their own independent review of the survey before distributing it to the randomly selected AAO members. Once the survey was approved by the AAO-PIR, it was distributed via email to 2,184 AAO members to collect responses.

Questions	Answer Choices
1. I have read and understand the “Online Survey Informed Consent” that was presented to me above by the Principal Investigator or study member.	a. Yes b. No
2. Please select your gender: Male or Female?	a. Male b. Female c. Non-disclosed
3. Please select the country where you practice?	a. USA b. International (Drop down menu with countries)
4. Which current career status best describes you?	a. Educator b. Private practice c. Hospital setting d. Corporate e. Military service a. Other (please describe) : _____
5. How long have you been practicing orthodontics?	a. Less than one year b. 1-5 years c. 6-10 years d. 11 -15 years e. More than 15 years
6. During your residency program, how many TADs did you place?	a. I never placed a TAD b. I placed one TAD c. I placed 2-3 TADs d. I placed 4-6 TADs e. I placed more than 6 TADs
7. How would you describe yourself regarding frequency of using TADs in your practice?	a. Never used. b. Rarely use. c. Use sporadically d. Use it frequently e. Other (describe): _____
8. In which clinical situation have you used your LAST SIX TADs? (select all that apply) To:	a. I never use it. b. Close extraction space c. Intrude anterior teeth d. Intrude posterior teeth e. Palatal expansion bone anchorage f. Maxillary protraction g. Distalize posterior segment (no extraction) h. Hold temporary crowns i. Other: _____
9. In your LAST SIX TADs, did you use most of them:	a. Unilaterally b. Bilaterally c. I never use TADs d. Other: _____

Figure 1. SurveyMonkey® questionnaire

Figure 1 continued

Questions	Answer Choices
10. In your opinion, for what clinical reason are TADs used the most in orthodontics? To:	<ul style="list-style-type: none"> a. Close extraction space b. Intrude anterior teeth c. Intrude posterior teeth d. Expand maxillary arch e. Maxillary protraction f. Distalize posterior segment (no extraction) g. Hold temporary crowns h. Other: _____
11. What is the type of the TADs you use the most in your orthodontic practice?	<ul style="list-style-type: none"> a. Ormco Corp b. 3M Oral Care c. American Orthodontics d. Comfort Solutions Inc. e. Dentaurum Inc. f. Dentsply Sirona g. Henry Schein Orthodontics h. Other (Please specify): _____
12. What is the length of the TAD you use the most?	<ul style="list-style-type: none"> a. Please specify in mm: ____ b. I don't know
13. What is the diameter of the TAD you use the most?	<ul style="list-style-type: none"> a. Please specify in mm: ____ b. I don't know
14. In your LAST SIX TAD's applications, how would you grade the rate of success?	<ul style="list-style-type: none"> a. All of them accomplished the goals b. One of them failed to accomplish the goals c. Two of them failed to accomplish the goals d. Three of them failed to accomplish the goals e. Four of them failed to accomplish the goals f. Five of them failed to accomplish the goals g. All six of them failed to accomplish the goals. h. Other (describe): _____
15. Please select the one best option about your TAD placement technique	<ul style="list-style-type: none"> a. Do not use anesthetic solution b. Use topical anesthetic solution c. Use infiltrative anesthetic solution d. I do not place TADs e. Other (please specify): _____
16. Please select the one best option about your TAD placement technique	<ul style="list-style-type: none"> a. I place TADs horizontal (perpendicular) to the teeth b. I place TADs vertical (parallel) to the teeth c. I place TADs oblique to the teeth d. I do not place TADs e. Other (please specify): _____
17. Please select the one best option about your TAD placement technique	<ul style="list-style-type: none"> a. Guidance hole drilling b. No guidance hole drilling c. I do not place TADs d. Other (please specify): _____

Figure 1 continued

Questions	Answer Choices
18. In your opinion, what are the TWO most frequent complication of TADs application?	a. Unwanted dental intrusion resulting open bite b. Unwanted dental mesio/distal inclination c. Unwanted buccal-lingual inclination d. Unwanted dental torque e. TAD mobility/loss f. TAD contacting teeth. g. Other: _____
19. Do you charge for TADs placement?	a. Yes. Each TAD is charged b. Yes. The price is embedded into the initial fee. c. No. My treatment fees can absorb the cost. d. Other: _____

II.2 Survey distribution and data collection

The 19-question survey was designed and administered through the Survey Monkey® software. The AAO PIR program was utilized to distribute the survey via email to a subset of AAO orthodontic members in the U.S., Canada, and Internationally. The survey was sent to 2,184 active, retired, and service orthodontists. The survey was also emailed to program directors and chairs of all orthodontic programs in the U.S. and Canada, asking to distribute the survey to their alumni, faculty, and any international organizations of their knowledge. The survey was also asked to be distributed to orthodontists around the world by the World Federation of Orthodontists. However, for technical reasons, this was not achieved. Participation was completely voluntary and respondents were required to agree to a consent statement prior to taking the survey. The survey was intended for orthodontists only, thus, any respondent who identified themselves as an orthodontic resident was eliminated from the statistical analysis. Survey Monkey® allowed only one response per participant if the participant accessed the survey through the same IP address. Personal email invitations to orthodontists requested participants to ignore the email if they had already completed the survey through AAO PIR. Responses were collected over a time period of approximately 6 months (October 2020-March 2021).

Participants were asked to share demographical information. The country and length of time practicing orthodontics were the two independent variables for this study and were used for comparative analyses. Originally, each country was to be used for comparative analysis but due to the number of responses, respondents were placed into one of three categories based on continent: North America, South America and Other, which encompassed Asia, Europe, Australia, and Antarctica, which were then used for comparison. Based on the answer provided, when asked the length of time practicing orthodontics, the respondents were either placed in the ≤ 10 years or ≥ 11 years category. There was a total of 256 responses, with approximately a 10% response rate based on the distribution number by the AAO PIR program since it was difficult to determine how many respondents were from the emails distributed by program directors and chair persons. One respondent indicated “no” to the consent, two respondents were retired and did not answer any questions, and two indicated they were a resident. Those five respondents were excluded giving a total of 251 responses to be included in the data analysis (Figure 2).

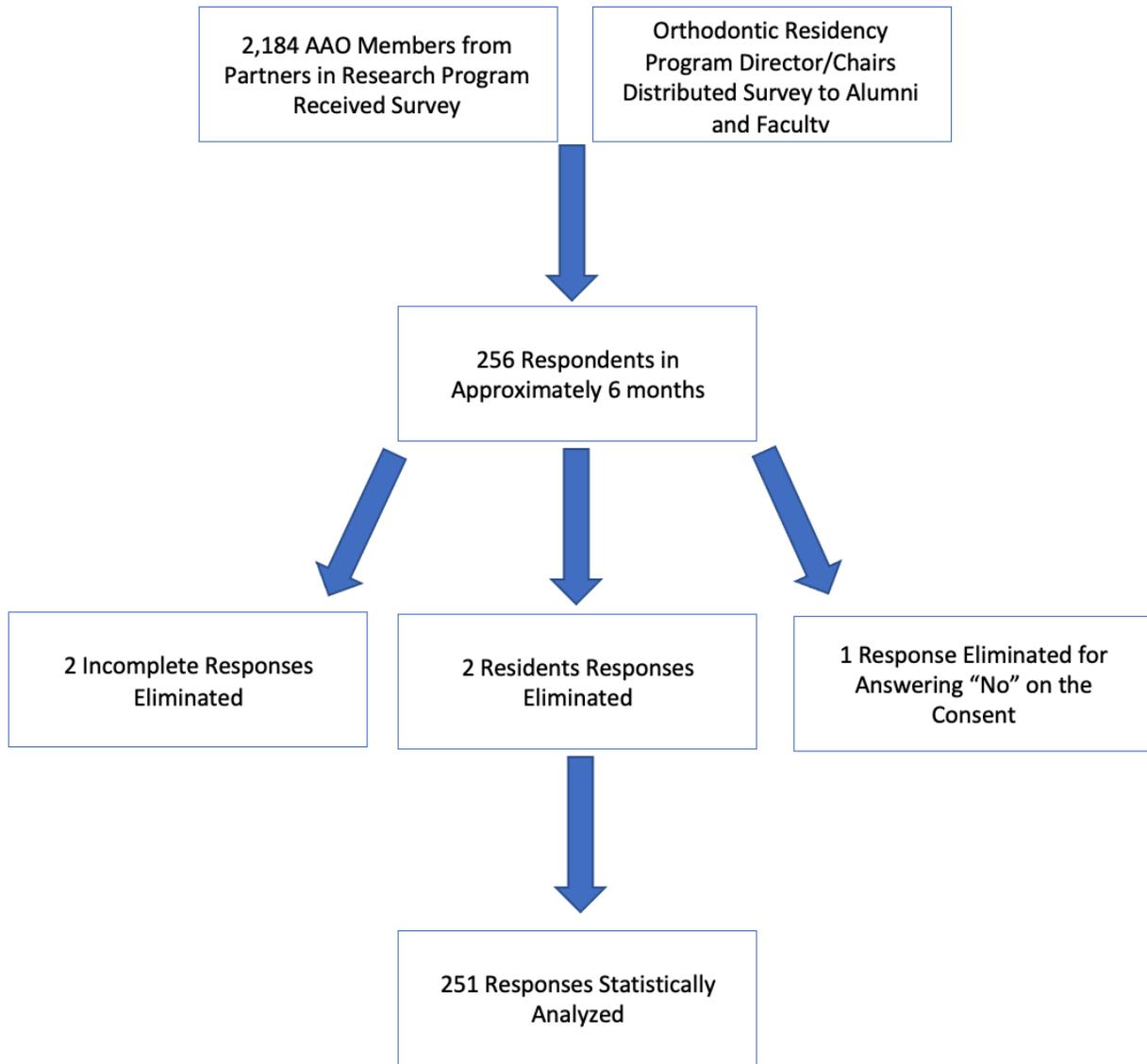


Figure 2. Survey distribution and filtration methods for statistical analysis

II.3 Statistical analysis

Descriptive statistics were calculated for all questions. Question # 3 (country of practice) was collapsed into a 3-category variable (continents): North America, South America, and Other continents (Europe/Africa/Australia/Asia) because of the number of responses. Question #5 (length of time practicing orthodontics) was collapsed into a 2-category variable (years of practice): ≤ 10 years and ≥ 11 years of practicing orthodontics. Other questions were collapsed

down to make the comparisons simpler and more significant. Chi-square or Fisher's Exact tests were used to see if the continent and years of practice variables were associated with the responses from questions about TAD application (Questions #6 to #19). Bonferroni correction, based on 2 tested hypotheses for each response of questions, was applied to count for the multiple comparisons which is why the test is considered statistically significant when $p < 0.025$. SPSS Statistics 28 software was used for the data analysis.

III Results

III.1 Descriptive statistics

According to Figure 3, 68.8% of respondents were male and 31.2% were females with most of the respondents practicing in the United States (65.2%). The majority worked in private practice (68.8%) and a good distribution was found amongst how long the respondents had been practicing orthodontics.

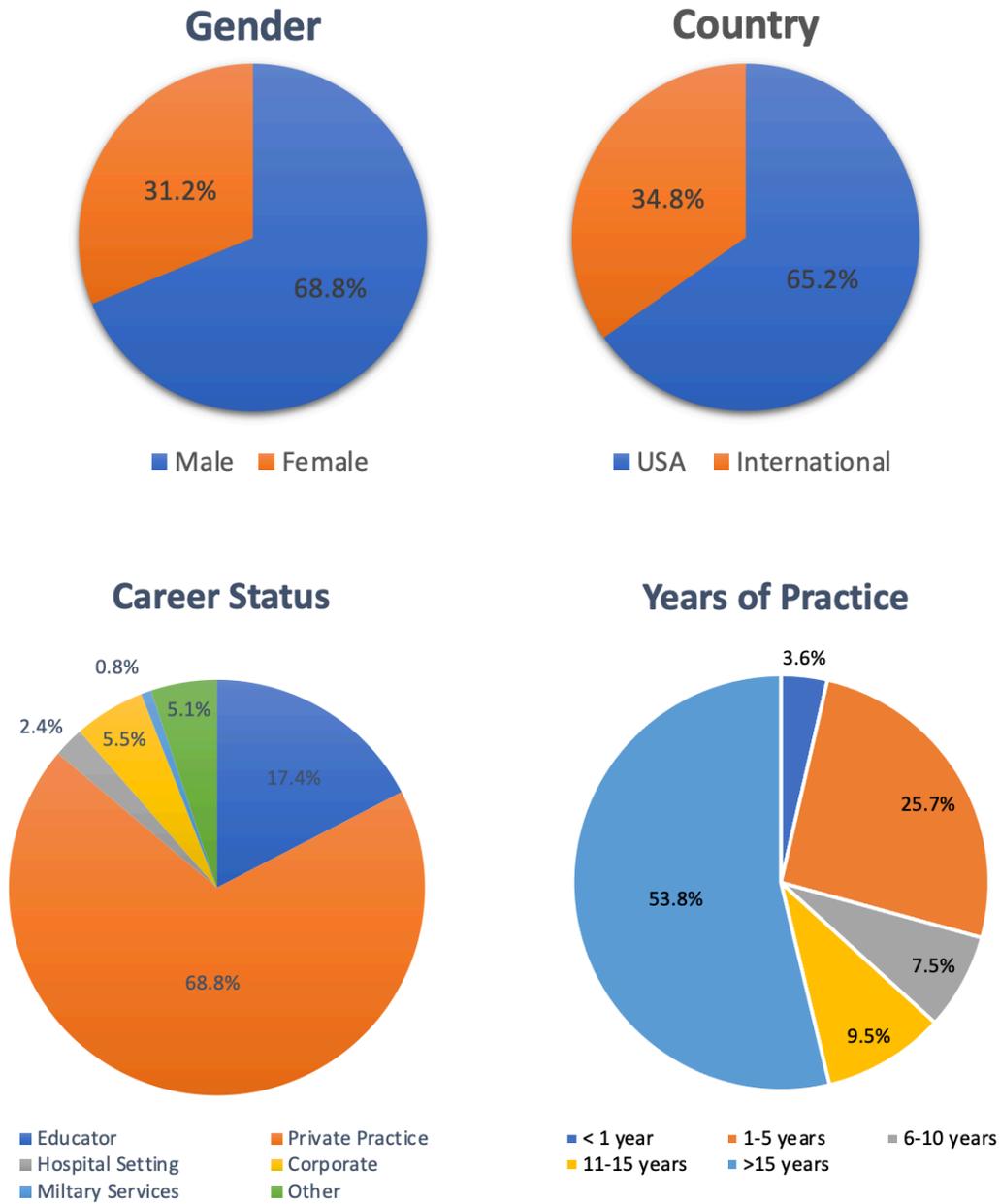


Figure 3. Demographic distribution

Table 1 shows that over half of respondents never placed a temporary anchorage device in their residency program, but only 15.4% of respondents indicated to having never used a TAD before, but most claimed to use TADs sporadically. Most orthodontists believed that TADs are used the most in orthodontics to close extraction spaces, followed by intrusion of posterior teeth,

and distalization of the posterior segment, respectively. Furthermore, most respondents indicated that the two most frequent complications with TADs in general are TAD mobility/loss (88.9%) followed by TAD contacting adjacent teeth (26.9%).

When asked about the last six TADs used for their own clinical cases, the majority answered close extraction spaces (56.1%) and intrude posterior teeth (50.2%). Most TADs were used bilaterally (58.7%), and over one third of the last six TADs (38.4%) were 100% successful (remained in the mouth), whereas 30.6% of the respondents indicated only one TAD failing. Only one respondent stated having all six TADs failed.

When asked about placement technique, most respondents use infiltrative anesthetic solution when placing TADs (57.0%). Regarding insertion technique, 31.6% stated to place TADs oblique to the teeth, 30.8% place TADs horizontal (perpendicular) to the teeth and only 6% place TADs vertically (parallel) to the teeth. Only 8.4% of respondents use a guide hole for TAD placement. Most respondents charge for TADs either individually or place the price in their initial fee, whereas a third of respondents do not charge for TADs. When asked about the type of TAD placed, most respondents chose the “other” option (40.7%), and the most common free response answers were Rocky Mountain Ortho and Morelli (a Brazillian company). Interestingly, respondents also stated that they use whatever TAD their oral surgeon or periodontist recommended when patients were referred for TAD placement.

Table 1. Frequency and percentage of full responses

	N	%
Q2. Gender (n=253)		
Male	174	68.8
Female	79	31.2
Q3. Country (n=253)		
USA	165	65.2
International	88	34.8

Table 2 continued

	N	%
Q4. Current career status (n=253)		
Orthodontic Educator	44	17.4
Orthodontic Private Practice	174	68.8
Orthodontic Hospital Setting	6	2.4
Orthodontic Corporate	14	5.5
Orthodontic Military Service	2	0.8
Other (please specify)	13	5.1
Q5. Years of practice orthodontic (n=253)		
Less than one year	9	3.6
1-5 years	65	25.7
6-10 years	19	7.5
11-15 years	24	9.5
More than 15 years	136	53.8
Q6. During your residency program, how many TADs did you place?		
I never placed a TAD	142	56.4
I placed one TAD	7	2.8
I placed 2-3 TADs	38	15.1
I placed 4-6 TADs	25	9.9
I placed more than 6 TADs	40	15.9
Q7. How would you describe yourself regarding frequency of using TADs in your practice?		
Never used.	39	15.4
Rarely use.	69	27.3
Use sporadically	93	36.8
Use it frequently	52	20.6
Q8. In which clinical situation have you used your LAST SIX TADs? (select all that apply) To:		
I never use it.	32	12.6
Close extraction space	142	56.1
Intrude anterior teeth	64	25.3
Intrude posterior teeth	127	50.2
Palatal expansion bone anchorage	51	20.2
Maxillary protraction	32	12.6
Distalize posterior segment (no extraction)	74	29.2
Hold temporary crowns	12	4.7
Other	26	10.3
Q9. In your LAST SIX TADs, did you use most of them:		
Unilaterally	68	27.0
Bilaterally	148	58.7
I never use TADs	32	12.7
Other (please specify)	4	1.6

Table 3 continued

	N	%
Q10. In your opinion, for what clinical reason are TADs used the most in orthodontics? To:		
Close extraction spaces	95	37.6
Intrude anterior teeth	16	6.3
Intrude posterior teeth	60	23.7
Expand maxillary arch	15	5.9
Maxillary Protraction	10	4.0
Distalize posterior segment (no extraction)	40	15.8
Hold temporary crowns	0	0.0
Other (please specify)	17	6.7
Q11. What is the type of the TAD you use the most in your orthodontic practice?		
Ormco Corp	48	19.9
3M Oral Care	26	10.8
American Orthodontics	15	6.2
Comfort Solutions Inc.	0	0.0
Dentaurum Inc.	44	18.3
Dentsply Sirona	6	2.5
Henry Schein Orthodontics	4	1.7
Other (please specify)	98	40.7
Q14. In your LAST SIX TAD's applications, how would you grade the rate of success?		
All of them accomplished the goals	94	38.4
One of them failed to accomplish the goals	75	30.6
Two of them failed to accomplish the goals	31	12.7
Three of them failed to accomplish the goals	16	6.5
Four of them failed to accomplish the goals	3	1.2
Five of them failed to accomplish the goals	0	0.0
All six of them failed to accomplish the goals	1	0.4
Other (describe)	25	10.2
Q15. Please select the one best option about your TAD placement technique		
I do not use anesthetic solution	2	0.8
I use topical anesthetic solution	39	15.5
I use infiltrative anesthetic solution	143	57.0
I do not place TADs	62	24.7
Other (please specify)	5	2.0
Q16. Please select the one best option about your TAD placement technique		
I place TADs horizontal (perpendicular) to the teeth	77	30.8
I place TADs vertically (parallel) to the teeth	15	6
I place TADs oblique to the teeth	79	31.6
I do not place TADs	60	24
Other (please specify)	19	7.6

Table 4 continued

	N	%
Q17. Please select the one best option about your TAD placement technique		
Guidance hole drilling	21	8.4
No guidance hole drilling	165	66.0
I do not place TADs	63	25.2
Other (please specify)	1	0.4
Q18. In your opinion, what are the TWO most frequent complications of TADs application?		
Unwanted dental intrusion resulting in an open bite	15	5.9
Unwanted dental mesio-distal inclination	17	6.7
Unwanted buccal-lingual inclination	26	10.3
Unwanted dental torque	9	3.6
TAD mobility/loss	225	88.9
TAD contacting teeth	68	26.9
Other (please specify)	23	9.1
Q19. Do you charge for TADs placement?		
Yes, each TAD is charged	75	30.49
Yes, the price is embedded into the initial fee	62	25.2
No, my treatment fees can absorb the cost	82	33.33
Other (please specify)	27	10.98

III.2 Comparative statistics by continent

Table 2 illustrates how questions 6-19 related to the continent variable, either North America, South America or Other (Europe, Asia, Australia and Antarctica). The majority of all three continent groups indicated using TADs rarely or sporadically. North American orthodontist's respondents indicated the highest number of professionals having never used TADs, whereas South American orthodontists had the highest percentage of using TADs frequently. Although not statistically significant, closing extraction spaces was found to demonstrate how most orthodontists utilized their last six TADs in all continent groups: 53.7% for North America, 63.9% for South America, and 62.5% for the remaining continents.

The second most common response about the previous six TADs utilized was to intrude posterior teeth, which showed to be statistically significant, followed by distalizing the posterior segment, which also proved to be statistically significant. South America had the majority of

responses (66.7%) for both of these answers, where North America only indicated distalizing posterior segment at 17.7%. Orthodontists from the other continents group (32.5%) chose the option of palatal expansion bone anchorage TAD usage more than the North (15.4%) and South (27.8%) America continent groups. When asked about the length of TADs, orthodontists in all categories chose 6-8mm as the most common response. Most North American orthodontists (58.2%) expressed not knowing the diameter of the TAD they use, while the South American (58.3%) and other continent orthodontists (70%) chose 1.1 to 2.0 mm as their most commonly used TAD diameter.

Infiltrative anesthetic solution had the highest response rate for TAD placement technique. The orthodontists in South America (77.8%) had the highest percentage, followed by other continents (65%) and then North America (52%). A very low percentage of orthodontists (2.8% from South America and 2.5% from the other continents group) said they don't use any anesthetic solution at all, and none of the North American respondents place TADs without anesthetic solutions.

Regarding the direction of TAD placement, most respondents stated they insert the TADs obliquely (55.6% South America, 23.3% North America, and 47.5% other continents group). However, 35.5% of North American orthodontists indicated placing TADs horizontal whereas only 16.7% of the South American group chose a horizontal placement technique. All three continent groups chose to insert their TADs without drilling a guide hole as their best option for TAD placement technique (68.4% North America, 67.5% other continents group, and 55.6% South America). When asked about charging for TADs, the North America group responded that their treatment fee can absorb the cost as their highest response (43.9%). Charging for each TAD was South America's (57.6%) and the other continents (42.1%) group's highest response.

Table 5. Descriptive statistics for Q6-19 by continents

		North America	South America	Other continents	
	Total	n (%)	n (%)	n (%)	P-Value
Q6. During your residency program, how many TADs did you place?					
I never placed a TAD	140	102 (58.3%)	20 (57.1%)	18 (45%)	0.528
I placed 1-3 TADs	45	32 (18.3%)	5 (14.3%)	8 (20%)	
I placed 4 or more TADs	65	41(23.4%)	10 (28.6%)	14 (35%)	
Q7. How would you describe yourself regarding frequency of using TADs in your practice?					
Never Used	38	35 (20%)	0 (0.0%)	3 (7.5%)	<0.001*
Rarely Used/Sporadically	161	121 (69.1%)	20 (55.6%)	20 (50.0%)	
Use Frequently	52	19 (10.9%)	16 (44.4%)	17 (42.5%)	
Q8. In which clinical situation have you used your LAST SIX TADs? (Select all that apply) To:					
I never use TADs	31	27 (15.4%)	1 (2.8%)	3 (7.5%)	0.067
Close Extraction Spaces	142	94 (53.7%)	23 (63.9%)	25 (62.5%)	0.379
Intrude Anterior Teeth	64	35 (20.0%)	14 (38.9%)	15 (37.5%)	0.01*
Intrude Posterior Teeth	127	83 (47.4%)	24 (66.7%)	20 (50%)	0.109
Palatal Expansion Bone Anchorage	50	27 (15.4%)	10 (27.8%)	13 (32.5%)	0.023*
Maxillary Protraction	32	21 (12%)	4 (11.1%)	7 (17.5%)	0.587
Distalize Posterior Segment (No Extraction)	74	31 (17.7%)	24 (66.7%)	19 (47.5%)	<0.001*
Hold Temporary Crowns	12	7 (4%)	3 (8.3%)	2 (5%)	0.469
Other	26	17 (9.7%)	3 (8.3%)	6 (15%)	0.587
Q9. In your LAST SIX TADs, did you use most of them:					
Unilaterally	68	53 (30.5%)	9 (25%)	6 (15%)	0.029
Bilaterally	147	90 (51.7%)	26 (72.2%)	31 (77.5%)	
I never use TADs	31	27 (15.5%)	1 (2.8%)	3 (7.5%)	
Other	4	4 (2.3%)	0 (0%)	0 (0%)	

Table 6 continued

		North America	South America	Other continents	
	Total	n (%)	n (%)	n (%)	P-Value
Q10. In your opinion, for what clinical reason are TADs used the most in orthodontics? To:					
Close Extraction Spaces	95	70 (40.7%)	11 (30.6%)	14 (36.8%)	a
Intrude Anterior Teeth	16	15 (8.7%)	0 (0%)	1 (2.6%)	
Intrude Posterior Teeth	59	41 (23.8%)	10 (27.8%)	8 (21.1%)	
Expand Maxillary Arch	14	12 (7%)	0 (0%)	2 (5.3%)	
Maxillary Protraction	10	10 (5.8%)	0 (0.0%)	0 (0%)	
Distalize Posterior Segment (No Extraction)	40	12 (7%)	15 (41.7%)	13 (34.2%)	
Other	12	12 (7%)	0 (0%)	0 (0%)	
Q11. What is the type of the TADs you use the most in your orthodontic practice?					
Ormco Corp	48	43 (29.1%)	1 (2.9%)	4 (10%)	a
3M Oral Care	26	19 (12.8%)	4 (11.8%)	3 (7.5%)	
American Orthodontics	15	10 (6.8%)	0 (0%)	5 (12.5%)	
Dentaurum Inc	44	39 (26.4%)	0 (0%)	5 (12.5%)	
Dentsply Sirona	6	3 (2.0%)	1 (2.9%)	2 (5%)	
Henry Schein Orthodontics	4	4 (2.7%)	0 (0%)	0 (0%)	
Other	79	30 (20.3%)	28 (82.4%)	21 (52.5%)	
Q12. What is the length of the TAD you use the most?					
6-8mm	121	85 (50.9%)	18 (50%)	18 (45%)	0.001*
9-12mm	30	18 (10.8%)	2 (5.6%)	10 (25%)	
>12mm	3	0 (0%)	0 (0%)	3 (7.5%)	
Other	16	13 (7.8%)	0 (0%)	3 (7.5%)	
I don't know	73	51 (30.5%)	16 (44.4%)	6 (15%)	

Table 7 continued

		North America	South America	Other continents	
	Total	n (%)	n (%)	n (%)	P-Value
Q13. What is the diameter of the TAD you use the most?					
0-1.0	4	2 (1.2%)	2 (5.6%)	0 (0%)	<0.001*
1.1-2.0	107	58 (34.1%)	21 (58.3%)	28 (70%)	
>2.0	7	4 (2.4%)	0 (0%)	3 (7.5%)	
Other	7	7 (4.1%)	0 (0%)	0 (0%)	
I don't know	121	99 (58.2%)	13 (36.1%)	9 (22.5%)	
Q14. In your LAST SIX TAD's applications, how would you grade the rate of success?					
All of them accomplished the goals	94	64 (43.8%)	14 (40%)	16 (42.1%)	0.317
1-2 failed to accomplish the goals	105	69 (47.3%)	15 (42.9%)	21 (55.3%)	
3-all 6 failed to accomplish the goals	20	13 (8.9%)	6 (17.1%)	1 (2.6%)	
Q15. Please select the one best option about your TAD placement technique					
I do not use anesthetic solution	2	0 (0%)	1 (2.8%)	1 (2.5%)	0.017*
I use topical anesthetic solution	38	32 (18.7%)	2 (5.6%)	4 (10%)	
I use infiltrative anesthetic solution	143	89 (52%)	28 (77.8%)	26 (65%)	
I do not place TADs	61	48 (28.1%)	5 (13.9%)	8 (20%)	
Other	3	2 (1.2%)	0 (0%)	1 (2.5%)	
Q16. Please select the one best option about your TAD placement technique					
I place TADs horizontal (perpendicular) to the teeth	76	61 (35.5%)	6 (16.7%)	9 (22.5%)	0.003*
I place TADs vertical (parallel) to the teeth	15	11 (6.4%)	2 (5.6%)	3 (5%)	
I place TADs oblique to the teeth	79	40 (23.3%)	20 (55.6%)	19 (47.5%)	
I do not place TADs	59	47 (27.3%)	4 (11.1%)	8 (20%)	
Other	19	13 (7.6%)	4 (11.1%)	2 (5%)	
Q17. Please select the one best option about your TAD placement technique					
Guidance hole drilling	21	7 (4.1%)	9 (25%)	5 (12.5%)	0.003*
No guidance hole drilling	164	117 (68.4%)	20 (55.6%)	27 (67.5%)	
I do not place TADs	62	47 (27.5%)	7 (19.4%)	8 (20%)	

Table 8 continued

		North America	South America	Other continents	
	Total	n (%)	n (%)	n (%)	P-Value
Q18. In your opinion, what are the TWO most frequent complication of TADs application?					
Unwanted dental intrusion resulting in an open bite	15	13 (7.4%)	1 (2.8%)	1 (2.5%)	0.491
Unwanted mesio-distal inclination	17	11 (6.3%)	3 (8.3%)	3 (7.5%)	0.791
Unwanted bucco-lingual inclination	25	16 (9.1%)	5 (13.9%)	4 (10%)	0.647
Unwated dental torque	9	4 (2.3%)	3 (8.3%)	2 (5%)	0.094
TAD mobility/loss	223	155 (88.6%)	33 (91.7%)	35 (87.5%)	0.863
TAD contacting teeth	68	47 (26.9%)	6 (16.7%)	15 (37.5%)	0.124
Other	23	18 (10.3%)	2 (5.6%)	3 (7.5%)	0.746
Q19. Do you charge for TADs placement?					
Yes. Each TAD is charged	75	40 (27%)	19 (57.6%)	16 (42.1%)	0.005*
Yes. The price is embedded in the initial fee	62	43 (29.1%)	6 (18.2%)	13 (34.2%)	
No. My treatment fees can absorb the cost	82	65 (43.9%)	8 (24.2%)	9 (23.7%)	

Note: Question #8 was analyzed separately for each choice (Yes/No)

*Statistically significant when $P < 0.025$

a. Cannot be computed because there is insufficient memory

III.3 Comparative statistics by years of practice

While comparing the groups with more or less than 10 years in private practice (Table 3), statistically significant differences were found. A large number (83%) of orthodontists in the ≥ 11 years in practice group never placed a TAD in residency whereas only 8.8% of orthodontists in the ≤ 10 years in practice group never placed a TAD while in residency. However, 47.3% of orthodontists practicing ≤ 10 years placed four or more TADs while in residency.

Both groups had the highest response for using TADs rarely or sporadically. Orthodontists in the ≤ 10 years of practice group responded never using TADs as their second highest response (23.1%) and using frequently as their lowest response (15.4%). The ≥ 11 years of practice group responded the opposite using TADs frequently as their second highest response (23.8%) and never

using as their lowest response (10.6%). Both groups responded with the majority not drilling a guidance hole as part of their insertion technique (78% ≤ 10 years of practice group, and 59.6% ≥11 years of practice group). Only 3.3% of respondents in the ≤ 10 years of practice group used guide holes, whereas 11.5% of respondents in the ≥11 years of practice group stated that they used guide holes.

Table 9. Descriptive statistics for Q6-19 by years of practicing orthodontics

		≤ 10 Years (N=93)	≥ 11 Years (N=160)	
	Total	n (%)	n (%)	P-Value
Q6. During your residency program, how many TADs did you place?				
I never placed a TAD	140	8 (8.8%)	132 (83%)	<0.001*
I placed 1-3 TADs	45	40 (44%)	5 (3.1%)	
I placed 4 or more TADs	65	43 (47.3%)	22 (13.8%)	
Q7. How would you describe yourself regarding frequency of using TADs in your practice?				
Never Used	38	21 (23.1%)	17 (10.6%)	0.018*
Rarely Used/Sporadically	161	56 (61.5%)	105 (65.6%)	
Use Frequently	52	14 (15.4%)	38 (23.8%)	
Q8. In which clinical situation have you used your LAST SIX TADs? (Select all that apply) To:				
I never use TADs	31	12 (13.2%)	19 (11.9%)	0.761
Close Extraction Spaces	142	51 (56%)	91 (56.9%)	0.898
Intrude Anterior Teeth	64	20 (22%)	44 (27.5%)	0.335
Intude Posterior Teeth	127	44 (48.4%)	83 (51.9%)	0.591
Palatal Expansion Bone Anchorage	50	18 (19.8%)	32 (20%)	0.967
Maxillary Protraction	32	11 (12.1%)	21 (13.1%)	0.813
Diztalize Posterior Segment (No Extraction)	74	21 (23.1%)	53 (33.1%)	0.093
Hold Temporary Crowns	12	2 (2.2%)	10 (6.3%)	0.22
Other	26	10 (11%)	16 (10%)	0.805

Table 10 continued

		≤ 10 Years (N=93)	≥ 11 Years (N=160)	
	Total	n (%)	n (%)	P-Value
Q9. In your LAST SIX TADs, did you use most of them:				
Unilaterally	68	22 (24.4%)	46 (28.7%)	0.854
Bilaterally	147	55 (61.1%)	92 (57.5%)	
I never use TADs	31	12 (13.3%)	19 (11.9%)	
Other	4	1 (1.1%)	3 (19%)	
Q10. In your opinion, for what clinical reason are TADs used the most in orthodontics? To:				
Close Extraction Spaces	95	34 (37.8%)	61 (39.1%)	0.584
Intrude Anterior Teeth	16	9 (10%)	7 (4.5%)	
Intrude Posterior Teeth	59	22 (24.4%)	37 (23.7%)	
Expand Maxillary Arch	14	6 (6.7%)	8 (5.1%)	
Maxillary Protraction	10	3 (3.3%)	7 (4.5%)	
Distalize Posterior Segment (No Extraction)	40	11 (12.2%)	29 (18.6%)	
Other	12	5 (5.6%)	7 (4.5%)	
Q11. What is the type of the TADs you use the most in your orthodontic practice?				
Ormco Corp	48	15 (18.5%)	33 (23.4%)	0.345
3M Oral Care	26	10 (12.3%)	16 (11.3%)	
American Orthodontics	15	10 (12.3%)	5 (3.5%)	
Dentaurum Inc	44	16 (19.8%)	28 (19.9%)	
Dentsply Sirona	6	2 (2.5%)	4 (2.8%)	
Henry Schein Orthodontics	4	1 (1.2%)	3 (2.1%)	
Other	79	27 (33.3%)	52 (36.9%)	
Q12. What is the length of the TAD you use the most?				
6-8mm	121	49 (54.4%)	72 (47.1%)	0.151
9-12mm	30	14 (15.6%)	16 (10.5%)	
>12mm	3	0 (0%)	3 (2%)	
Other	16	7 (7.8%)	9 (5.9%)	
I don't know	73	20 (22.2%)	53 (34.6%)	

Table 11 continued

		≤ 10 Years (N=93)	≥ 11 Years (N=160)	
	Total	n (%)	n (%)	P-Value
Q13. What is the diameter of the TAD you use the most?				
0-1.0	4	0 (0%)	4 (2.6%)	0.073
1.1-2.0	107	42 (46.7%)	65 (41.7%)	
>2.0	7	4 (4.4%)	3 (1.9%)	
Other	7	5 (5.6%)	2 (1.3%)	
I don't know	121	39 (43.3%)	82 (52.6%)	
Q14. In your LAST SIX TAD's applications, how would you grade the rate of success?				
All of them accomplished the goals	94	38 (46.9%)	56 (40.6%)	0.596
1-2 failed to accomplish the goals	105	37 (45.7%)	68 (49.3%)	
3-all 6 failed to accomplish the goals	20	6 (7.4%)	14 (10.1%)	
Q15. Please select the one best option about your TAD placement technique				
I do not use anesthetic solution	2	0 (0%)	2 (1.3%)	0.263
I use topical anesthetic solution	38	14 (15.4%)	24 (15.4%)	
I use infiltrative anesthetic solution	143	58 (63.7%)	85 (54.5%)	
I do not place TADs	61	17 (18.7%)	44 (28.2%)	
Other	3	2 (2.2%)	1 (0.6%)	
Q16. Please select the one best option about your TAD placement technique				
I place TADs horizontal (perpendicular) to the teeth	76	34 (37.4%)	42 (26.8%)	0.306
I place TADs vertical (parallel) to the teeth	15	7 (7.7%)	8 (5.1%)	
I place TADs oblique to the teeth	79	26 (28.6%)	53 (33.8%)	
I do not place TADs	59	17 (18.7%)	42 (26.8%)	
Other	19	7 (7.7%)	12 (7.6%)	
Q17. Please select the one best option about your TAD placement technique				
Guidance hole drilling	21	3 (3.3%)	18 (11.5%)	0.007*
No guidance hole drilling	164	71 (78%)	93 (59.6%)	
I do not place TADs	62	17 (18.7%)	45 (28.8%)	

Table 12 continued

		≤ 10 Years (N=93)	≥ 11 Years (N=160)	
	Total	n (%)	n (%)	P-Value
Q18. In your opinion, what are the TWO most frequent complication of TADs application?				
Unwanted dental intrusion resulting in an open bite	15	8 (8.8%)	7 (4.4%)	0.156
Unwanted mesio-distal inclination	17	8 (8.8%)	9 (5.6%)	0.337
Unwanted bucco-lingual inclination	25	12 (13.2%)	13 (8.1%)	0.198
Unwated dental torque	9	2 (2.2%)	7 (4.4%)	0.494
TAD mobility/loss	223	82 (90.1%)	141 (88.1%)	0.631
TAD contacting teeth	68	29 (31.9%)	39 (24.4%)	0.199
Other	23	11 (12.1%)	12 (7.5%)	0.226
Q19. Do you charge for TADs placement?				
Yes. Each TAD is charged	75	30 (36.6%)	45 (32.8%)	0.729
Yes. The price is embedded in the initial fee	62	24 (29.3%)	38 (27.7%)	
No. My treatment fees can absorb the cost	82	28 (34.1%)	54 (39.4%)	

Note: Question #8 was analyzed separately for each choice (Yes/No)

*Statistically significant when P<0.025

IV Discussion

The first goal of this study was to include orthodontists from different parts of the world to determine how often TADs were being used clinically. However, a worldwide survey investigation presented the challenge of a language barrier when creating the survey. By including orthodontists from around the world, the authors had to rely on the ability of orthodontists to read and respond to the questionnaire in English. Ultimately, the authors decided that AAO international members should be assumed to speak some English, at least to be able to answer a questionnaire. The second goal was to create a consensus and establish guidelines for how TADs should be implemented in everyday practice, determine the most common sizes utilized, placement techniques, success rates,

and common causes for failure. TAD usage amongst different age groups of orthodontists was also investigated.

Each category in this survey could be a research topic in and of itself, potentially creating a steady transition into future research. Additional or different questions and answer choices could have also been added to the survey. However, to strengthen the power of statistical analysis, the authors limited the alternative choices.

IV.1 TAD utilization by continents

A difference in how orthodontists from different parts of the world utilize TADs in their everyday practice was found. Although all continents were very similar in how many TADs they placed while in residency, orthodontists from North America were more likely to have never used a TAD or only use them rarely or sporadically. Based on the answers provided by the respondents, TADs are used more often in South America and other continents than they are in North America. However, there was no definition given in the survey for the rarely/sporadically vs. frequently answer choices, thus the data could be skewed because respondents were not certain how to measure their frequency of TAD usage. Also, some orthodontists could have declined participating in the survey since they knew they didn't use TADs as part of their treatment plans.

The most frequent reason orthodontists from around the world are using TADs is to close extraction spaces, which is no surprise since studies have shown that anchorage loss is minimized by TAD utilization,^{32, 33} and have even shown to preserve anchorage approximately two more millimeters over traditional maximum anchorage methods.³² They are also commonly used to intrude both anterior and posterior teeth.^{6, 34} TADs can be used to correct excess gingival display, otherwise known as “gummy smile” by anterior intrusion in cases with vertical maxillary excess as a less invasive option to orthognathic surgery.³⁵ TADs also give suitable correction of moderate

anterior open bites and growing hyperdivergent, Class II patients by maxillary molar intrusion and controlling the vertical dimension by maintaining mandibular molar position.^{36, 37} Distalizing the posterior segment in non-extraction cases was more commonly performed in South America than anywhere else according to those who responded to this survey.

Additional write-in answers indicated respondents using TADs for tooth impaction cases, molar uprighting, anchorage reinforcement, and closing spaces in congenitally missing or previously extracted cases. Furthermore, they stated that TADs were used bilaterally more often than unilaterally throughout the world. On the other hand, multiple respondents shared they were using TADs palatally, which was not an alternative choice provided in the survey. One respondent also stated that they equally use TADs unilaterally and bilaterally, which was not an answer choice provided in the survey forcing respondents to choose one or the other.

When asked about their own opinion regarding clinical situations in which TADs are most utilized, many respondents said to close extraction spaces, which correlates well with how TADS were used in respondents' last six personal TAD cases. The same goes for intruding posterior teeth. However, not many respondents believe orthodontists are using TADs to intrude anterior teeth. No South American respondents believe that TADs are used mostly to intrude anterior teeth, however, they had the highest response rate for intruding anterior teeth in their last six TAD cases. South American respondents, as well as orthodontists from the other continents group, had a substantially higher response for believing TADs are being used for distalizing the posterior segment, which also compares to how they are actually using TADs during their own treatments. Respondents from North America thought that TADs were being utilized to intrude anterior teeth more than any other country's respondents, but all three groups have a similar view when it comes to intruding posterior teeth with TADs.

The rationale for choosing to ask respondents specifically about their last six TADs instead of just asking about their perception of TAD utilization allowed for respondents to give a detailed and accurate representation of TAD performance in their personal cases. Six was a small enough number where orthodontists could quickly recall the information on placement technique and performance rather than deterring respondents with such a large number and subsequently making the survey time too long. On the other hand, it could be a reflection of a specific and limited amount for orthodontists who use large quantities of TADs.

IV.2 Types of TADs by continent

North American orthodontists were mostly using TADs fabricated by Ormco®, followed by Dentaurem® and 3M Oral Care® TADs respectively. South America and other continents chose “other” as their most common answer. Out of the 99 comments added to this question, the most popular companies were Morelli (a Brazillian company) (18), followed by “I don’t know” (10), RMO (6), and Forestadent (6). Some respondents stated not knowing the brand since oral surgeons or periodontists placed their TADS. It is the authors’ belief that perhaps there is no significance for which brand of TADs to use, as long as the TAD remains in place until the anchorage requirement is achieved, but availability, price, convenience, and other factors may play a significant role in choosing a brand of TADs.

Regarding length and diameter of TADs used throughout the world, 30% of respondents did not know the length of TAD used and about 50% did not know the diameter of TAD used in their last six cases. However, this is understandable since TADs can be used for many different orthodontic anchorage mechanics, thus, they can be placed in different areas of the mouth, hence the need for different sizes. The most commonly used length around the world was between 6.0mm-8.0mm and the most commonly used diameter was between 1.1mm-2.0mm, both of which

are statistically significant. A systematic review showed that TADs that are at least 8.0mm in length and 1.2mm in diameter are preferred and have better success rates with minimal risk of root damage.³⁸ Some authors believe that success due to the diameter of the TAD differs between the maxilla and mandible, and that a diameter of 1.4mm or less produces better success in the maxilla whereas a diameter of greater than 1.4mm is more successful in the mandible.³⁹ It is believed that smaller diameter TADs have a higher success rate than larger ones, such as 2.0mm, which have low success rates.⁴⁰

IV.3 TAD placement technique by continent

TAD placement techniques from around the world proved to be very similar, which was statistically significant for type of anesthetic solution, placement angulation, and guide hole preference. The majority in all three continent groups used infiltrative anesthetic solution. This contradicts with previous research stating that topical anesthetic is sufficient for patient comfort during placement.^{6, 14} Orthodontists from North America use only topical more than anywhere else in the world, and no one from North America stated they would use no anesthetic at all.

Orthodontist respondents from North America prefer a more horizontal (perpendicular) placement, whereas orthodontists from everywhere else have a more oblique insertion preference. There was not a very high response rate for vertical (parallel) placement from any continent group. It has been recommended that an oblique to horizontal placement in the maxillary arch will decrease the incidence of root perforation, whereas an oblique insertion angle in the mandibular arch increases the surface area of cortical bone.^{34, 41} Furthermore, some authors recommend to start insertion horizontally and gradually change the angulation to oblique.⁴²

TAD insertion without using a guide hole was also the preference of all different continent respondents, however about a quarter of South Americans did use a guide hole. This could be due

to the professional's experience and preference, a certain TAD design that recommends a guide hole prior to placement, or even an insertion site with thick cortical bone such as the posterior mandible, which would warrant using a guide hole.

Charging for TADs proved to be significantly different throughout the world. North American orthodontists are more likely not to charge for TADs and let their treatment fees absorb the cost, whereas charging for each TAD that is placed is more common outside of North America.

IV.4 TAD success and failures by continents

The overwhelming majority of orthodontist respondents from around the world believe that TAD mobility/loss and TADs contacting adjacent teeth are the two most frequent complications when using TADs. Many factors are reported in the literature that contribute to TAD failure, however in one study the distance between the TAD and adjacent root proved to be the most significant factor related to TAD failure.^{39, 43} TAD success rates throughout the world were very similar in this study for the participants' last six TAD cases. The highest response for all three categories stated that 1-2 TADs failed to accomplish the goals, and a 100% success rate was close behind in each group. This implies that for the majority of the respondents, 16.5 % to 33 % of the TADs failed to accomplish their goals. However, there was no clear definition of success in this survey. Some respondents could have rated success as the TAD staying in the mouth and not becoming mobile, whereas other respondents could have used poor mechanics resulting in unachieved treatment goals and viewed this as a failure. Success is difficult to measure with TADs because there is no clear-cut definition. A systematic review where most of the studies defined success as lack of mobility, absence of inflammation, and performing intended functions for longer than 4 months reported $\geq 90\%$ success rates³⁹, different from the result of this study, which only took into account the six last TADs placed by orthodontists.

IV.5 TAD utilization by age difference

Even though 83% of orthodontists that have been practicing for ≥ 11 years never placed a TAD during residency, the frequency of use amongst the different age groups is very similar (rarely/sporadically). Even though it was statistically insignificant, the biomechanics, types of TADs being used, success rates, and opinions about TAD utilization are all very similar as well between the younger (≤ 10 years) and the older (≥ 11 years) groups. Their placement techniques are also very comparable, however a guide hole is slightly more common in the older age group. This is most likely due to guide holes being the only technique used before 2009.⁴⁰

A roughly equal distribution was found while discussing how each age group charged for TADs. Most respondents stated that they charged for each TAD or the charges were included in their initial fee. However, a trend was found amongst the older orthodontist group indicating they didn't charge for TADs, but it was not statistically significant. This could possibly be because they are more financially stable from practicing longer or they already had higher treatment fees that could cover for the price of TADs utilized without having to charge them individually.

IV.6 Remarks, biases, and limitations

This study supports the hypothesis that TAD utilization varies in different parts of the world, even though there were similarities in certain aspects. However, the results reject the hypothesis that orthodontists practicing ≥ 11 years will use TADs less often than orthodontists practicing 10 years or less.

The potential for bias in this study includes respondents answering questions when they did not even utilize TADs, as well as the finite number of answer choices with a large realm of possibilities on how to answer some of the questions. Limitations to this study included having a small sample size, asking only about the last six TADs used, and distributing the survey only in

English. Asking only about the last six TADs gives very restricted data and could have led to skewed results. Furthermore, providing the survey only in English while expecting worldwide contribution limited the respondents and deterred orthodontists who wanted to participate but were non-English-speaking. This could have been part of the reason for the small sample size and could potentially invalidate some responses if participants could not understand the questions or answers due to a language barrier. Future research questions could include inquiries about success rates in the maxillary arch versus the mandibular arch, indirect versus direct anchorage utilization and immediate loading versus non-immediate loading.

V Conclusion

The frequency of use with respect to TADs is similar around the world. Orthodontist respondents around the world, outside of South America, indicated that TADs are more frequently used to close extraction spaces. Orthodontists from South America are using TADs more frequently to distalize the posterior segment. The most commonly utilized TAD mechanics around the world differed, however the frequency of use and placement techniques were similar, and therefore the first hypothesis was rejected. The most common length and diameter used are 6-8mm and 1.1-2.0 mm, respectively. This study did reject the hypothesis that orthodontists who have been practicing for over 10 years will not use TADs as frequently as orthodontists who have been practicing for 10 years or less. Although there was significant data found in this study, there is such variability when it comes to TAD insertion techniques, mechanics, experience, and patients that it makes it difficult to create specific guidelines for TAD placement. While this study was a step in the right direction for achieving that goal, additional studies are needed. It is recommended to break down each category further in order to achieve clearer results.

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