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Ten years of miniscrew use in a U.S. orthodontic residency program

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Introduction: Orthodontic miniscrews have become popular not only because they can provide an absolute form of anchorage, but also because they can reduce the required patient compliance when compared with traditional orthodontic anchorage. The objective of this study was to examine success rates of miniscrews placed by orthodontic residents and to evaluate which factors may affect insertion outcomes. **Methods:** The sample consisted of 109 consecutive miniscrews placed in 60 patients (27 males and 33 females). Miniscrews were placed at 4 different insertion sites (anterior palate [n = 31], palatal alveolar process [n = 25], maxillary buccal alveolar process [n = 15], and mandibular buccal alveolar process [n = 38]). Analysis of variance tests were used to evaluate the influence of insertion sites and anchorage type (direct vs indirect) on the success rate. **Results:** The overall success rate for miniscrews was 72.5%. The success rate was 83.9% in the anterior palate, 76% in the palatal alveolar process, 60% in the maxillary buccal alveolar process, and 65.8% in the mandibular buccal alveolar process. The success rate was significantly higher in indirect anchorage (84.2%) compared with direct anchorage (58.8%). **Conclusions:** Palatal miniscrews were more successful than buccal miniscrews. Indirect anchorage mechanics had a higher success rate than direct anchorage mechanics. (Am J Orthod Dentofacial Orthop 2020;158:834-9)

Anchorage control in orthodontic treatment is essential for good treatment outcomes. Orthodontic miniscrews have become very popular not only because they can provide an absolute form of anchorage, but also because they can reduce or eliminate patient compliance when compared with traditional orthodontic anchorage methods. They have become more sophisticated and easy to use compared with the initial attempts using osteosynthesis screws.[1] Currently, miniscrews come in various shapes and sizes, with different head designs allowing the installation of sophisticated biomechanics.[2,3] As a result, they have become an integral part of modern orthodontic treatment and are being used in the majority of U.S. orthodontic residencies.

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
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Submitted, July 2019; revised and accepted, November 2019.
0889-5406/$36.00
© 2020.
https://doi.org/10.1016/j.ajodo.2019.11.015

Although multiple studies have reported miniscrew success rates and have made attempts to correlate them to various factors such as insertion torque, jaw, age, or sex, findings are contradictory, and the screws in these studies were typically placed by experts in the field.[4-9] To date, no study has attempted to evaluate success rates for inexperienced users. The present study, therefore, aimed to evaluate how successful orthodontic miniscrews are being used by residents in a university-based accredited U.S. orthodontic training program.

MATERIAL AND METHODS

This study was approved by the Institutional Review Board at Case Western Reserve University. Patient charts for cases using miniscrews in the orthodontic clinic from 2006 to 2016 were examined retrospectively. The sample consisted of 109 consecutively placed miniscrews in 60 patients (27 male and 33 females; average age, 18.5 years; minimum age, 13.3 years; maximum age, 41.9 years). A power analysis determined that the minimum required sample size required was 52. All miniscrews were placed by orthodontic residents under the supervision of a single instructor (S.B.) in the orthodontic clinic at Case Western Reserve University. All miniscrews placed were titanium-alloy tomas SD pins (Dentaurum, Ispringen, Germany) (Fig 1) in 6-mm, 8-mm, and 10-mm length as was determined by local factors, with

Fig 1. Dentaurum's tomas pin.

a universal inner diameter of 1.2 mm and an outer diameter of 1.6 mm. Screws were placed with manual drivers, either straight or contra-angle, depending on the site, and generally without a predrilling procedure, unless the cortical bone at the site was determined to be excessively thick (>1.5 mm). Here, a simple cortical bone perforation was undertaken with a 1 mm diameter round bur and irrigation with sterile saline solution. Insertion sites were categorized into 4 areas: anterior palate (AP) (Fig 2), palatal alveolar process (PP) (Fig 3), maxillary buccal alveolar process (MXP) (Fig 4), and mandibular buccal alveolar process (MDP) (Fig 5). The type of anchorage used was categorized into a direct anchorage and indirect anchorage. The miniscrew is considered to have failed if it becomes loose before achieving the desired treatment goal. The mobility of the screw was determined by visual inspection and manipulation at every appointment. For each patient, the following data were collected: sex, age, site of insertion, date of

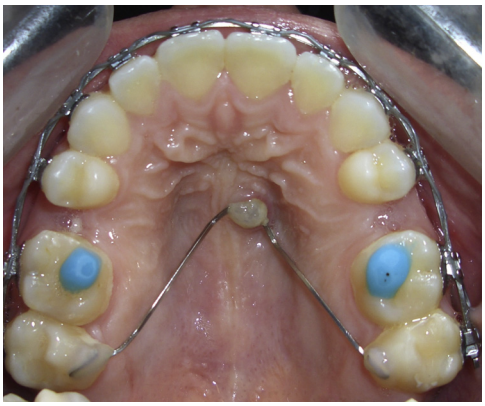

Fig 2. The anterior palate as an insertion site for miniscrews, indirect anchorage mechanics.

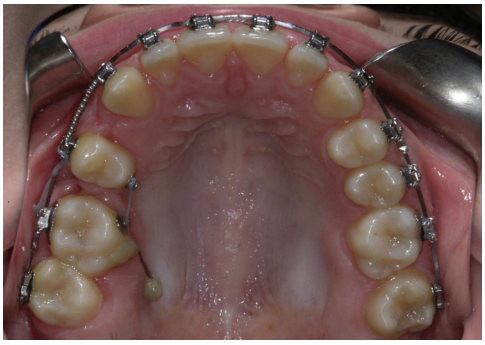

Fig 3. The posterior palatal alveolar process as an insertion site for miniscrews, indirect anchorage mechanics.

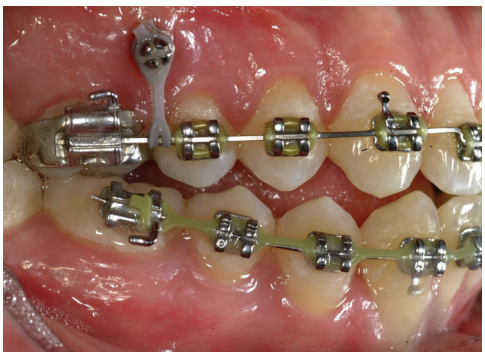

Fig 4. The maxillary buccal alveolar process as an insertion site for miniscrews, direct anchorage mechanics.

mini-implant insertion and removal, and type of anchorage used.

Statistical analysis

SPSS statistical software (version 17.0; SPSS Inc, Chicago, Ill) was used for all statistical analyses, and

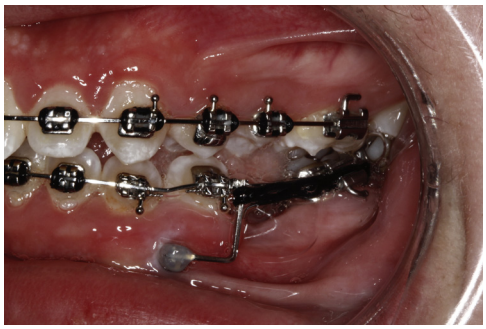

Fig 5. The mandibular buccal alveolar as an insertion site for miniscrews, indirect anchorage mechanics.

significance levels for all tests were set at a *P* value of 0.05. Analysis of variance tests were used to evaluate the influence of insertion sites and anchorage type (direct vs indirect) on the success rate with Tukey post-hoc test evaluating further interactions of the different variables.

Results

The overall success rate for miniscrews placed by orthodontic residents was 72.5%. The success rate was 83.9% in the AP, 76% in PP, 60% in the MXP, and 65.8% in MDP (Table I). Multiple post-hoc group comparisons showed a significant statistical difference when comparing the AP and PP with the buccal insertions sites. However, there was no statistical difference when comparing the MDP to the MXP (Table II).

The success rate was significantly higher in indirect anchorage (82.8%) compared with direct anchorage (58.8%). The 31 miniscrews placed in the AP were all used with indirect anchorage with a success rate of 83.9%. In the PP, 16 miniscrews were used with indirect anchorage with a success rate of 87.5%, and 9 miniscrews were used with direct anchorage with a success rate of 55.5%. In the MXP, 2 miniscrews were used for indirect anchorage with a success rate of 50%, and 13 miniscrews were used with direct anchorage with a success rate of 61.5%. In the MDP, 9 miniscrews were used with indirect anchorage with a success rate of 88.8%, and 29 were used with direct anchorage with a success rate of 58.6% (Table I).

Table I. Success and failures at different insertion sites

	Insertion site											
	AP			*PP*			*MXP*			*MDP*		
Sex	*S*	*F*	*Total*	*S*	*F*	*Total*	*S*	*F*	*Total*	*S*	*F*	*Total*
Female	17	1	18	10	3	13	5	6	11	17	6	23
Male	9	4	13	9	3	12	4	0	4	8	7	15
Total	26	5	31	19	6	25	9	6	15	25	13	38
Success rate (%)	83.9			76			60			65.8		

S, success; *F*, failure.

Table II. Post-hoc analysis of different insertion sites ($P \geq 0.05$)

Insertion sites	*Insertion sites*	*Significance*
Anterior palate	Palatal alveolar process	0.003
	Maxillary buccal alveolar process	<0.0001
	Mandibular buccal alveolar process	<0.0001
Palatal alveolar process	Anterior palate	0.003
	Maxillary buccal alveolar process	<0.0001
	Mandibular buccal alveolar process	0.001
Maxillary buccal alveolar process	Anterior palate	<0.0001
	Palatal alveolar process	<0.0001
	Mandibular buccal alveolar process	0.884
Mandibular buccal alveolar process	Anterior palate	<0.0001
	Palatal alveolar process	0.001
	Maxillary buccal alveolar process	0.884

DISCUSSION

It is essential for a resident to successfully treat a wide range of malocclusions during the orthodontic residency; moreover, it is imperative that the clinical education leads a resident to insert orthodontic miniscrew implants confidently, so they are well prepared for the world of private practice.[10] However, this is not always easily achieved because albeit a minimally invasive procedure, it is invasive nevertheless, and although the orthodontic treatment plan may affect where the screw is placed, the local anatomy at the insertion site will affect how the implant site is prepared, and ultimately the screw is placed.[11] This implant site preparation can encompass anything from small mucosal incisions or fenestrations and predrilling pilot holes to simply properly numbing the patient in the case of an exclusively transmucosal insertion[11] In any event, the insertion of an orthodontic miniscrew resembles much more a procedure carried out by a periodontist, oral surgeon, or a general dentist than something an orthodontist traditionally does in their daily practice. This limited experience may explain why the routine application of miniscrews has not permeated every orthodontic practice yet, despite their indisputable utility. It would also serve as an explanation of why miniscrews may be used but not systematically taught in many residency

programs in the county. At this time, there are not enough experienced instructors around to teach in every postgraduate orthodontic course. The other part of that equation is that, especially in the university setting, it does not seem to be clear who should assume this teaching responsibility. Should the insertion of orthodontic miniscrews be taught by the more procedure-oriented surgical instructors (periodontists and oral surgeons), or—because orthodontists are the "end users" and do not just plan where the screw should go but also how it will be loaded—should orthodontists be the ones teaching even the surgical aspects of miniscrew use? At Case Western Reserve University, we certainly believe that the latter is the preferable option and have done so for years. This opinion led to the implementation of the first treatment clinic focused on skeletal anchorage cases in an orthodontic residency, over 10 years ago.

In the present study, all miniscrews were inserted under the direct supervision of the first author, by orthodontic residents who had been in the residency for a minimum of 6 months. However, in the majority of cases, they were much further along when they first inserted miniscrews because most screws were placed when leveling and alignment were complete. Residents had undergone a 5-hour didactic course, which concluded with a written multiple-choice examination to ensure theoretical proficiency and a practical exercise on typodonts or on each other to ensure clinical proficiency. These steps should ensure residents were able to both understand the treatment planning aspects of miniscrew use (problem solving) and the practical aspects with special emphasis on the insertion (procedure execution). This was the background and training of the residents that placed the screws in this study, and in the authors' opinion should meet or exceed the average level of experience of orthodontic practitioners in the U.S. even today, but certainly during the study period of 2006-2016. However, this by no means made them experts. It simply created a good foundation for the insertion of miniscrews.

The purpose of this study was to evaluate the success rate of miniscrews placed by orthodontic residents as a proxy for the success rates inexperienced clinicians can expect if properly trained. The success rate of miniscrews reported in literature ranged from 70% to 95%.[4-9] Therefore, our findings fall within that range and are comparable to success rates published in a previous study where the miniscrews were placed in the Orthodontic Department at the University of Kentucky. Although in that study patients were recruited from both graduate and faculty practices, it was not specified who inserted the miniscrews.[12]

Although the success rates reported in our study do fall within the current literature's range, they certainly are on the lower end and therefore probably too low for routine use of miniscrews in private practice in which the margin for error tends to be much smaller than in the forgiving teaching environment of a university.

One explanation, on the surface, the perhaps most probable one, would be that these were the first screws these residents had placed in their life, and the lack of experience may have affected the insertion outcomes negatively. This result would corroborate the findings of Kim et al[13] that experience is an important factor in miniscrew success. However, miniscrews were planned with help and placed under the supervision of a very experienced miniscrew user, according to a precisely defined, evidence-based clinical protocol. This protocol should compensate for or at least mitigate the lack of experience of the residents. Another explanation could be that looking at the location distribution of the screws, nearly half of all screws were placed in the buccal alveolar process, which is known to have higher failure rates than, for example, the palate.[8,9] However, another reason for a lower average success rate is that these data include secondary insertions, meaning that in the case of screw failures when it was determined that the patient was still in need of a miniscrew, it was reinserted. The literature indicates that secondary insertions come with a significantly lower success rate. Although most studies do not comment on the inclusion of secondary insertions in their sample, it must be assumed that at least some studies only focused on primary insertions, which artificially inflates success rates.[14]

However, it should be interpreted as positive that residents on their very first attempts of miniscrew use fared as well as other, more experienced users, given proper education and supervision. In addition, if more screws had been placed in the palate, one can extrapolate that overall failure rates would have been lower, matching the median failure rate in the literature more closely.

The decision on where to place an orthodontic miniscrew is usually based on several factors, such as treatment goal, biomechanics used, and local anatomy, and the choice of insertion site may impact the clinical success rates.[15] Local anatomy is usually subject to considerable individual variation, but certain insertion sites appear to exhibit reliable and reproducible patterns.[16-19] Cortical bone thickness is correlated directly to insertion torques and bone depth and affects the risk of contralateral perforation, which are important factors when planning and placing an orthodontic miniscrew. Both variables were evaluated by Baumgaertel et al,[15] and it was found that for the palate, both metrics were most favorable in the AP at the level of the first and second premolars. Consistent with current literature,[20] the miniscrews placed in the AP were the most successful,

with a success rate of 83.9%, which should be attributed to the favorable anatomy found at this site. An ideal amount of cortical bone thickness and bone depth and the lack of roots—proximity to which must be considered a serious cause for miniscrew failures[21-23]—make this a very suitable site for miniscrews, and a site that should be considered prime choice, especially for beginners. The second most successful insertion site was the PP, with a success rate of 76%. The PP was also evaluated by Baumgaertel,[17] who concluded that cortical bone thickness and bone depth of the PP are similarly favorable for the insertion of miniscrews, and although roots are present in the alveolar process, when placing miniscrews from the palate, one can benefit from considerable interradicular distance at specific sites.[24,25]

Overall, in our study, the buccal insertion sites had a lower success rate than 70%—a statistically significant difference to the palatal sites. Baumgaertel and Hans[18] examined the anatomy of the buccal cortical bone thickness and recommended that clinicians should know the pattern of the bone in this area to aid in miniscrew site selection because it can vary tremendously and may impact success rates. In addition to having cortical bone that is not uniformly suitable for the insertion of miniscrews, avoiding roots when executing insertions on the buccal is rather difficult.[24,25]

Another interesting finding was the effect of anchorage type (direct vs indirect) on the success rate—a variable that, to our knowledge, has not been investigated to date. In our study, the success rate was significantly higher with indirect anchorage (82.8%) compared with direct anchorage (58.8%). This finding suggests that directly applying a force to the miniscrew may be less successful than connecting the miniscrew to the dentition used as an anchor unit and thereby indirectly loading it. However, the fact that anterior palatal miniscrews were used exclusively with indirect anchorage may artificially inflate the benefits of this loading method, when in reality, it was the location of the screw that created these good outcomes. In this study, it will be hard to separate the true cause for the superior outcomes for indirect anchorage, but it can be noted that at least indirect anchorage did not adversely affect the success rates.

A limitation of this study was that no skeletal variables were investigated. There is some compelling evidence[9] that high angle mandibular plane angle cases will experience reduced success rates for buccal insertions, but in the authors' interpretation of these findings, this is due once again to the thickness of the cortical bone. Dolicocephalic cases tend to have thinner cortical bone, offering less primary stability, which can lead to early failures.[11] Because cortical bone thickness was considered in the planning and placement of miniscrews in this residency program, the facial pattern was indirectly accounted for in the present study. It has also been shown that skeletal pattern is irrelevant for palatal insertions.[13]

CONCLUSIONS

With proper training, beginners can achieve acceptable miniscrew success rates, especially in the palate, where even with little experience, superior results can be expected. Beginners should therefore gravitate to insertions in the AP. Miniscrews used with indirect anchorage had a higher success rate than screws used with direct anchorage. However, more research is required in this area to clarify the impact of biomechanics on success rates further.

SUPPLEMENTARY DATA

Supplementary data associated with this article can be found, in the online version, at https://doi.org/10.1016/j.ajodo.2019.11.015.

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