OVERVIEW

Guidelines for Success in Placement of Orthodontic Mini-Implants

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(Editor's Note: In this quarterly column, JCO provides an overview of a clinical topic of interest to orthodontists. Contributions and suggestions for future subjects are welcome.)

Various skeletal anchorage devices were introduced in the late 20th century, including prosthodontic implants, zygoma ligatures, palatal onplants and implants, retromolar implants, miniplates, and surgical screws.[1] The latter, which became known as temporary anchorage devices (TADs), have become increasingly popular because they are small and easy to insert and remove, they can be loaded immediately after insertion, and they can provide absolute anchorage for many types of orthodontic treatment, with no need for special patient compliance.[2-5] The use of orthodontic mini-implants is not without risks and complications, however; reports of miniscrew failure rates and causes have been published by numerous authors.[6-16]

Miyawaki and colleagues, in a study of 134 titanium screws of three different types, found that factors related to miniscrew failure included a screw diameter of 1mm or less, inflammation of the peri-implant tissues, and a high mandibular plane angle associated with thin cortical bone.[6] In a prospective study involving 44 patients treated with a total of 140 mini-implants, Cheng and colleagues reported a success rate of 89%; risk factors were identified as reduced bone quality and quantity at the insertion sites, soft-tissue characteristics such as absence of keratinized mucosa, and peri-implant bacterial infection.[7] More recently, Park and colleagues identified the jaw in which the miniscrew is placed, the side of placement relative to individual oral hygiene, and the lack of primary

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TABLE 1
MINISCREW SUCCESS RATES FOR VARIOUS LOADING TIMES

Authors	Year	Sample Size	Time of Loading	% Success
Miyawaki et al.[6]	2003	134	Variable	83.9-85.0
Fritz et al.[15]	2004	36	During first 4 weeks	70.0
Cheng et al.[7]	2004	140	After 2 weeks	89.0
Park et al.[8]	2006	227	Variable	91.6
Chen et al.[9]	2006	59	After 2 weeks	84.7
Motoyoshi et al.[10]	2006	124	Immediate	85.5
Tseng et al.[11]	2006	45	After 2 weeks	91.1
Kuroda et al.[12]	2007	116	Immediate-12 weeks	81.1-88.6
Luzi et al.[13]	2007	140	Immediate	90.7
Wiechmann et al.[14]	2007	133	Immediate	86.8
Chen et al.[16]	2007	273	Delayed	76.4-82.6

stability as additional factors.[8]

In either jaw, anterior implant placement has reportedly been more successful than posterior placement because of the detrimental effects of mastication forces.[8,11,12] Chen and colleagues concluded that screw length is a factor in success or failure after finding a higher success rate for 8mm implants (90.2%) than for 6mm implants (72.2%).[9] Motoyoshi and colleagues suggested that adequate placement torque was important to success,[10] while Luzi and colleagues emphasized the importance of proper insertion technique.[13] Wiechmann and colleagues found a significantly lower success rate for implants inserted in the lingual aspect of the mandible compared to other locations.[14]

The timing of orthodontic force loading—immediate, early, or delayed—has been discussed as a possible factor in TAD failure.[17] A delay before loading was recommended for the first skeletal anchorage systems, but immediate loading is now accepted, as supported by several histological[18-20] and clinical[10,13,14] studies. The success rates found in previous studies do not differ widely according to the time of loading (Table 1).

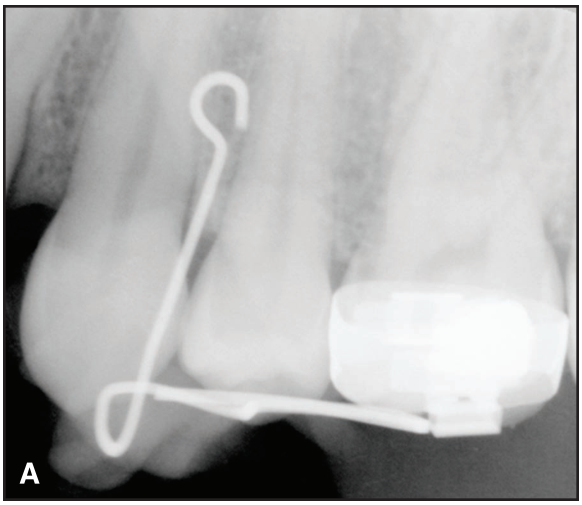
Despite the considerable research already published on miniscrew failures, most of these studies have been retrospective, have involved a limited number of patients, and do not include detailed descriptions or analyses of the reasons for failure. In this article, we report the results of a prospective clinical study that was conducted to improve our understanding of the factors involved in mini-implant success.

Materials and Methods

The study involved 137 adolescent and adult patients (52 male and 85 female) treated with fixed appliances at the Department of Orthodontics, School of Dentistry, Aarhus University, Denmark. All patients were informed about mini-implant procedures and risks and provided written consent to participate in the study. The indications for skeletal anchorage included insufficient teeth for the application of conventional anchorage, a high risk of adverse side effects on the anchorage units, planned asymmetrical tooth movements, the need for tooth movement to generate bone for prosthodontic implants, and special anchorage requirements to avoid orthognathic surgery. Aarhus Mini-Implants* with a length of 9.6mm or 11.6mm and a diameter of 1.5mm or 2mm were used in all patients.

A total of 211 miniscrews were inserted, 82

*Registered trademark of Medicon, Tuttlingen, Germany; www.medicon.de.



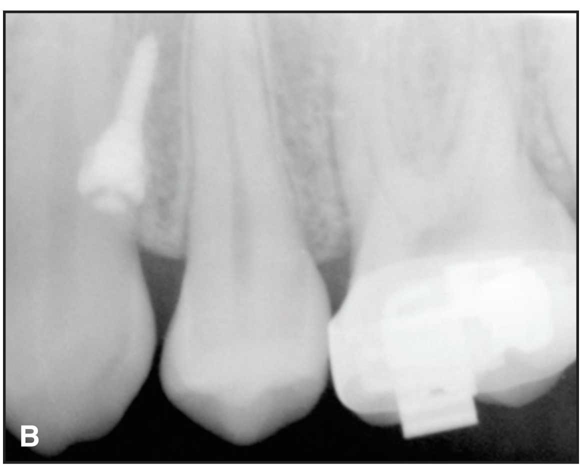


Fig. 1 A. Custom-made orthodontic wire template positioned over desired insertion area. B. After miniscrew insertion.

Fig. 2 Various Aarhus Mini-Implants* used in study.

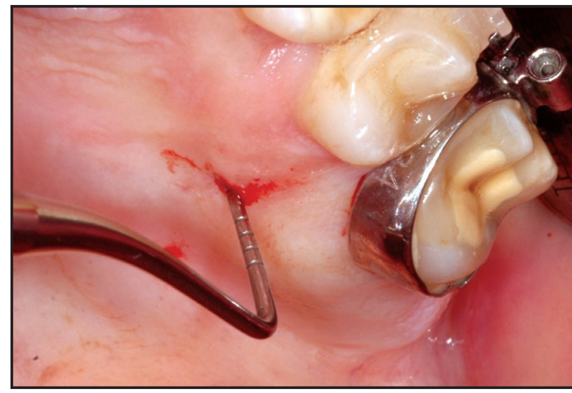


Fig. 3 Measurement of soft-tissue thickness in palatal area with periodontal probe.

in the maxilla and 129 in the mandible. The insertion sites, determined according to the planned dental movements and available bone, included the alveolar processes of both jaws, the palate, the mandibular symphysis, and the upper and lower retromolar areas. To evaluate the anatomical details of each insertion site, a periapical radiograph was taken using a custom-made template (Fig. 1). This radiograph was used to guide the selection of a miniscrew of appropriate size and shape (Fig. 2).

After administration of local anesthesia, the mucosa surrounding the insertion site was rinsed with a .02% chlorhexidine solution for two minutes. The soft-tissue thickness was measured with a periodontal probe or an endodontic file at the same inclination as the desired insertion angle of the miniscrew (Fig. 3). Because the mini-implants were self-drilling and self-tapping, it was not necessary to raise flaps for transmucosal insertion, although in areas of thick cortical bone (the mandibular symphysis and lower retromolar areas), a pilot hole was drilled using a low-speed bur and light pressure under constant irrigation. Each miniscrew was inserted with a manual screwdriver until the entire threaded portion was inside the bone, with only the head visible in the oral cavity.

After insertion, all miniscrews were immediately loaded, either directly or indirectly, using low forces of 50-100g from superelastic closed-coil springs (Fig. 4). In some cases, the skeletal

TABLE 2
MINISCREW FAILURE RATES
BY INSERTION SITE

Site	No. Implants	No. Failures	%
Maxillary alveolar process	70	5	7.1
Mandibular alveolar process	100	9	9.0
Mandibular symphysis	19	2	10.5
Palate	12	2	16.7
Retromolar area	10	1	10.0

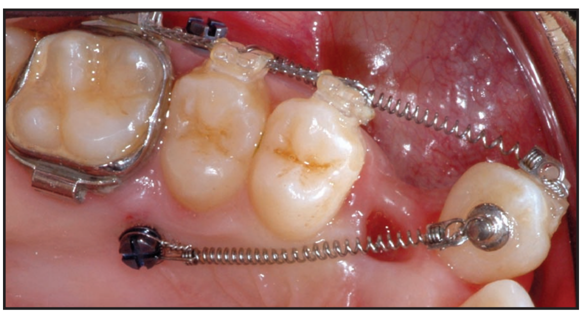


Fig. 4 Direct loading of miniscrews used as anchorage for canine retraction.

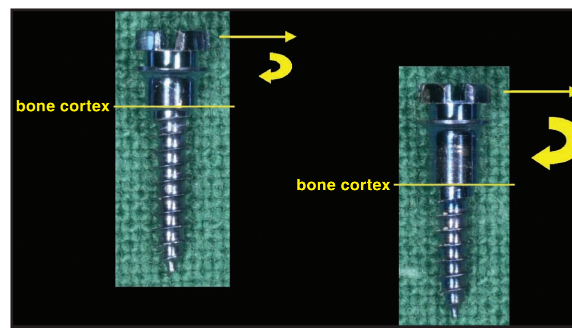


Fig. 5 Increased torsional force and moment generated on miniscrew by increasing distance between point of force application and resistance level (bone cortex).

anchorage was combined with other anchorage methods to achieve dental movements such as incisor intrusion and proclination, incisor retraction, premolar intrusion, midline correction, premolar distal movement, molar intrusion and uprighting, molar uprighting and mesial movement, molar intrusion and mesial movement, and molar mesial movement. Patients were given precise oral hygiene instructions, and all miniscrews were left in place until the desired tooth movements had been achieved. The miniscrew placement was considered successful if the implant withstood continuous mechanical loading for at least 120 days.

Results

Nineteen of the 211 miniscrews (9.0%), placed in 15 different patients, failed and had to be removed (Table 2). Eight of these were in the upper jaw (9.8% of the maxillary miniscrews) and 11 in the lower jaw (8.5% of the mandibular miniscrews). The failures occurred at five different anatomical sites. Because the number of failures was considered low relative to the number of possible causes of failure, the analysis was performed without statistical testing.

Causes of failure were divided into three categories: dentist-related (incorrect surgical procedure), patient-related (bone characteristics, soft-tissue thickness, inflammation or poor hygiene, and increased bone metabolism), and implant-related (screw breakage) (Table 3). Each of these factors accounted for between two and five failures, or between 1.0% and 2.4% of the total miniscrews inserted.

Discussion

The overall implant success rate of 91% in our study is slightly higher than the rates reported in most of the previous studies reviewed. Although other authors have reported higher success rates for maxillary implants,[8-11,15,16,21] the mandibular implants in our sample were slightly more successful than the maxillary implants (91.5% vs. 90.2%).

TABLE 3
CAUSES OF MINISCREW FAILURE

Category	Cause	No.	Patient Initials	%
Dentist-related	Incorrect surgical procedure	2	M.M., L.E.	1.0
Patient-related	Bone characteristics	5	B.H.(3), M.N., N.R.	2.4
	Soft-tissue thickness	4	H.O., B.L., R.D., R.M.	1.9
	Inflammation/hygiene	4	Y.S., D.E.(2), R.B.	1.9
	Increased bone metabolism	2	C.W., M.N.	1.0
Implant-related	Screw breakage	2	A.S., C.H.	1.0
TOTAL		19	15 patients	9.0

The higher density of mandibular bone is probably conducive to primary stability, but negative factors such as mastication forces and surgical difficulties related to the anatomical structure of the mandible may outweigh this advantage, especially in the posterior segments.

Incorrect insertion technique has been identified as a primary cause of failure in implant dentistry.[22] For orthodontic miniscrews, transmucosal flapless insertion after decontamination of the site with a chlorhexidine rinse is standard procedure, since flap surgery or mucoperiosteal incisions would cause more pain and discomfort.[12] Inadequate irrigation of the surgical site, excessive drill speed, wiggling movements of the screwdriver, and insufficient placement torque are among the most common mistakes. Operator experience is thus an important factor in reducing failure rates.[13,15]

Patient-related causes of possible failure should be thoroughly evaluated before miniscrew placement. There seems to be general agreement that the sex and age of the patient are unimportant; only Chen and colleagues, in a retrospective study of 129 patients, found that patients younger than 30 had a higher risk of failure than older patients.[16] On the other hand, anatomical issues seem to be highly significant. Insertion sites with extremely thin cortical bone provide less primary stability, but thick soft tissue may reduce the proportion of the miniscrew engaged in the bone and increase the torsional moment on the implant, due to the increased distance between the point of force application and the screw's center of resistance (Fig. 5). As in general implant dentistry, systemic diseases associated with increased bone metabolism or negative bone balance, such as osteoporosis and uncontrolled diabetes, can also reduce the chances of success.

Fig. 6 Screw broken during insertion.

Inflammation of the peri-implant soft tissues is another potential factor[6-8,13] that caused the loosening of four miniscrews in the present study. Strict oral hygiene, including thorough brushing of the miniscrew head with a soft toothbrush after every meal, is needed to minimize the risk of inflammation. Insertion of the device in the attached gingiva is recommended to avoid interference with the functional movements of the soft tissues apical to the mucogingival line. Anti-inflammatory drugs should not need to be routinely prescribed.[17]

Although miniscrews are now designed to withstand standard orthodontic forces of torsion and flexion,[5] improper insertion or removal can cause breakage, as with two screws in our sample (Fig. 6). The advent of self-drilling miniscrews has facilitated insertion, reducing the amount of torsional force required, but it may still be necessary to drill or enlarge a pilot hole if substantial resistance to insertion is encountered.

The risk of injury to dental roots during placement is one of the greatest concerns with orthodontic mini-implants, especially when they are inserted between teeth. Placement of a miniscrew too close to a root can also result in insufficient bone remodeling around the screw and transmission of occlusal forces through the teeth to the screws, which can lead to implant failure.[21] Even though periodontal structures can heal after being injured by TADs,[23] it is important to select insertion sites carefully, using thorough clinical and radiographic evaluation of their anatomical details.

Conclusion

Mini-implant failure can involve factors related to the clinician, the patient, and the screw itself. Large, multicenter studies are needed to shed additional light on the processes involved in skeletal anchorage so that failure rates can be reduced even further.

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