Clinical Outcome of Mini-Screws Used as Orthodontic Anchorage

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ABSTRACT

Background: Implants and orthodontics are an important combination to obtain intraoral anchorage and eliminate the disadvantages linked with extraoral anchorage such as compliance problems, aesthetical, and social factors. The mini-screw is a simple, relatively low-cost method to provide intraoral anchorage.

Purposes: The aims of this study were to evaluate clinical success and longevity of mini-screws during orthodontic treatment and to assess the patient's opinion.

Materials and Methods: Fifty mini-screws were inserted in the mandible and maxilla of 21 patients with a flapless technique under local anesthesia. The patients were recalled after 2 weeks and from then on every other 2 months, and periodontal parameters and stability of the screws were evaluated at regular intervals. Patients received a questionnaire to assess their opinion regarding the treatment.

Results: Thirty-three mini-screws (64%) remained stable sufficiently long to obtain the effect during the orthodontic movement. The survival was comparable in mandible or maxilla, and not related to the orthodontic forces applied or time of activation of the load. The results do suggest that a waiting period of 1 week before loading improves success, and mini-screws inserted into the anterior region score better also compared to the posterior region. Initial periodontal parameters, which are very important in prognosis of orthodontic treatment, are not influencing the success rate in the examined group. Patients complained in 40–50% of the cases of pain during or after surgery, but this did not negatively affect the final general satisfaction with the treatment.

Conclusion: The mini-screw implant is an easy and an inexpensive method for temporary anchorage of orthodontic appliances. The functioning time is short, however, and retreatment may often be required.

KEY WORDS: mini-implant, orthodontic anchorage, orthodontic movement

Adequate anchorage is considered fundamental for successful orthodontic regulation and is defined as the resistance to unwanted tooth movement. Extraoral fixation and traction can be provided by means of the occipital and cervical headgear, but they demand exceptional patient's cooperation and compliance is often difficult to achieve. Dental implants were introduced in the 1980s to provide intraoral rigid fixation of orthodontic appliances. They are practical when the patient cannot wear the extraoral devices ideally because they hamper aesthetics or social function, or when noncompliance is likely.[1] Osseointegrated dental implants are useful as rigidly connected osseous anchorage units because they lack a periodontal ligament and they do not move when forces are applied.[2] If properly planned, they can be incorporated in fixed prosthetic rehabilitations once the orthodontic tooth regulation is finished.[3] The need for further restoration can be an unwanted side effect because it prolongs the overall treatment time and involves higher financial costs. To overcome these disadvantages, implants were inserted in the anterior region of the palate.[4] This is a rather simple surgical procedure accomplished with a flapless procedure.[5] An alternative treatment is the installation of a titanium mini-plate

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fixed with three mini-screws on the interior border of the zygomatico-maxillary buttress between the first and second molars.[6] The disadvantage of this system is the complexity of the surgical procedure and the irritation caused by the elastics or coil springs in close contact with the mucosal tissues. Recently, titanium mini-implants were introduced. They are placed in cortical bone between roots or in diastemas in a one-stage flapless procedure at rather low cost, with minimal discomfort and without extensive healing time. The small dimensions of the screws allow them to be placed in unlimited receptor sites, and they are aimed to be removed easily once they have provided their anchoring effect. Removal is a simple procedure and does not require anesthesia or suturing. The wound will heal spontaneously within a few days, and bone healing is described as uneventful.[7] The success of mini-screws is described to range between 70 and 89%,[8–12] although comparison between different studies is limited by inconsistent reporting periods and subjective criteria of implant success or survival.

The aims of this clinical study were: (1) to describe the clinical efficacy of the mini-screw used as anchorage in orthodontic treatment according to a newly introduced survival classification, and (2) to obtain the patient's opinion on the treatment procedure. The ethics committee of Ghent University Hospital approved the study (EC/UZG/2005/097), and informed consent was signed by the patient or the parents in case of minors.

MATERIALS AND METHODS

Patient Selection

Patients were referred by specialists from the orthodontic department of the University Hospital during a 1-year period, and all were planned and treated by one periodontist in training (MJ). Mini-screws were located interdentally between roots or on the alveolar crest of the mandible or maxilla as an anchorage point for retrusion or protrusion of one or multiple teeth. Patients were given oral hygiene instruction or professional prophylaxis with scaling and polishing in order to obtain gingival health prior to treatment with less than 20% plaque or gingival bleeding.[13]

Mini-Screw Installation

The receptor sites were chosen after radiographic examination with orthopantomograms (12 patients) or with additional periapical radiographs (nine patients). A surgical guide was used in some patients with critical implant location. Mini-screws (Figure 1) were installed under local anesthesia of the soft tissues at the implant receptor site. The entire procedure was accomplished flapless under sterile conditions. The gingiva was perforated with a punch drill. The recipient site was prepared with a pilot drill of 1.1 or 1.4 mm depending on the implant size at 400–500 rpm under profound irrigation. To achieve the best primary stability, the longest and thickest implant was chosen without damaging teeth or anatomic structures.[14] The mini-screw was inserted with a manual or handpiece screwdriver, and considered

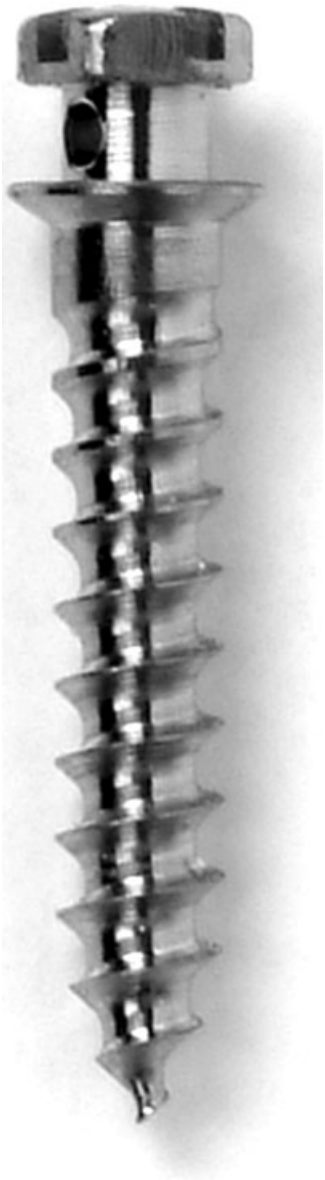

Figure 1 Example of the mini-screw used.

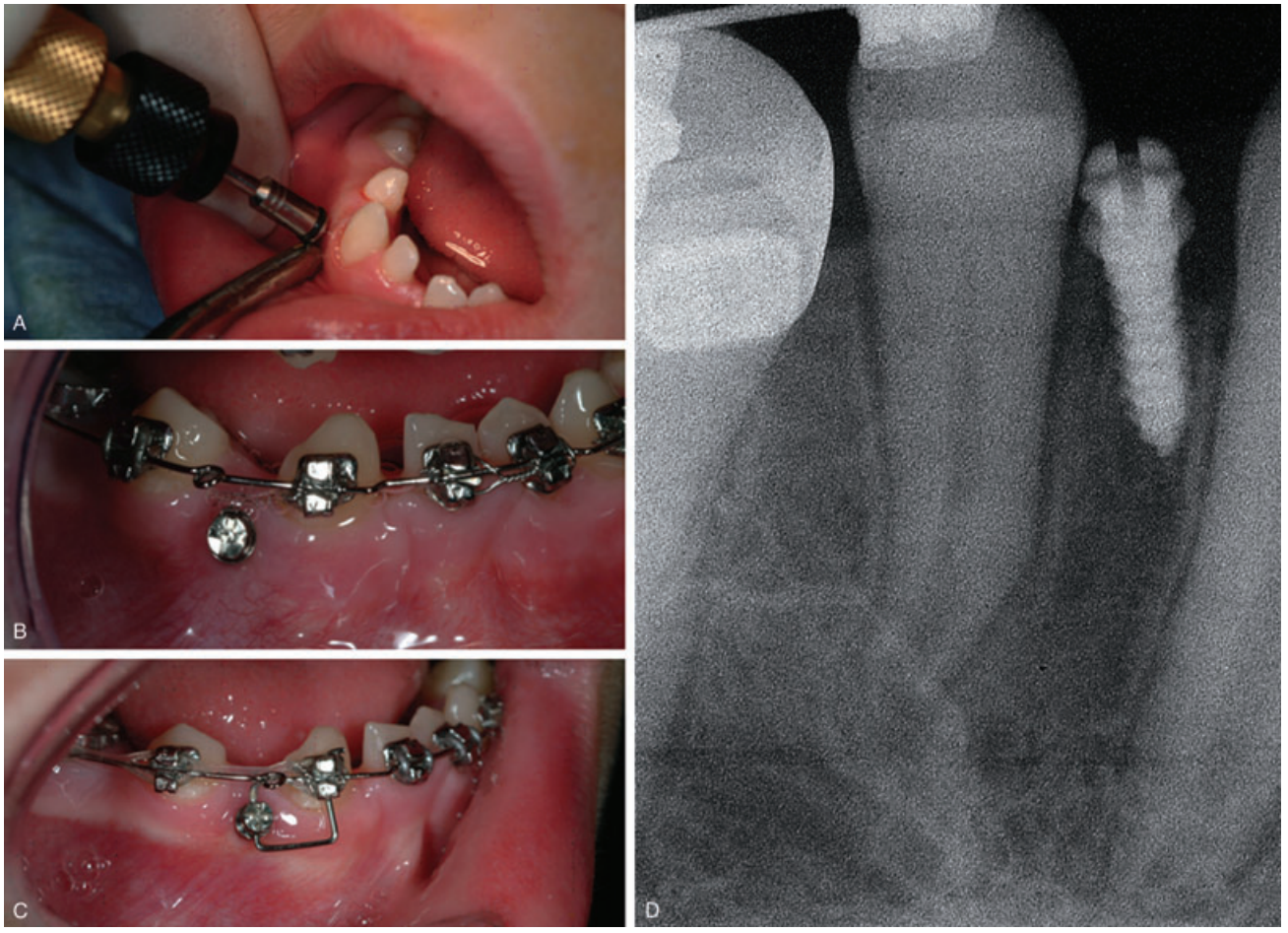

Figure 2 Clinical case showing (A and B) screw placement under local anesthesia, (C) screw with orthodontic appliance in place, and (D) radiograph indicating screw position in the diastema.

immobile and stable at the moment of placement. After installation, a periapical radiograph was taken to evaluate the position of the mini-screw. Because of the variations in angulations of the screws into the bone, it is impossible to use these radiographs for bone evaluation. Figure 2 shows a clinical case. After the surgical procedure, the patient was informed about oral hygiene with an extra-soft toothbrush (TePe, Malmö, Sweden) and advised the use of a 0.12% chlorhexidine mouth rinse. Antibiotics and painkillers were not prescribed.

Recall and Follow-Up

Patients were recalled 2 weeks postoperatively, and from then on every 2 months during the orthodontic treatment. Gingival health was assessed measuring bleeding as a reaction on gentle pressure around the mini-screw as well as plaque accumulation. A dichotomous index was used with score 1 being "presence" and 0 being "absence." The stability of the mini-screw was evaluated by rocking it between two mirror handles and scored at each visit with score 2 = mobility > 1 mm; score 1 = mobility < 1 mm, and 0 = no mobility at all. The patient's reaction after percussion of the screw was registered and if this caused pain, the implant was considered a failure. Prior to the start of the orthodontic treatment, the patients were asked to fill in a questionnaire in order to assess endured discomfort during surgery and postsurgically as well as the general experience and opinion regarding the treatment result.

Survival Criteria

Because the mini-screw is not intended for osseointegration and its removal is depending on the outcome of the orthodontic result, the usual criteria normally proposed for scientific evaluation, such as immobility or minimal bone remodeling,[15] are invalid or of clinical insignificance. A clinical score indicative of clinical survival and treatment objective was therefore used. Score 1 = perfect result, the implant remained stable as anchorage unit for the appliance as long as required

TABLE 1 Implant Location in Relation to Failure Rate

	Mandible	Maxilla	Total
Location	Failure/Inserted	Failure/Inserted	Failure/Inserted
Anterior	0/3	0/1	0/4
Premolars	6/20	2/10	8/30
Molars	7/11	2/5	9/16
	13/34	4/16	17/50

necessary during the orthodontic treatment; score 2 = the implant did not survive until the complete orthodontic treatment was finished, but the orthodontist did not require a new screw to finalize the treatment; score 3 = the implant showed an insufficient orthodontic result, and the replacement of the screw or an alternative treatment was necessary to fulfill the treatment needs; and score 4 = the implant was lost before orthodontics started, in general within 2 weeks after surgery, and could be considered as a complete failure.

RESULTS

Twenty-one patients (13 females, 8 males) with a mean age of 21.4 years (range 11–47) were treated with a total of 50 Dual-Top® mini-screws (see Figure 1) (R.M. Orthodontics, Denver, CO, USA) of 8 mm ($n = 8$) or 10 mm ($n = 42$) length, and 1.6 mm ($n = 28$) or 2 mm ($n = 22$) wide. Thirty-four implants were placed in the mandible and 16 in the maxilla.

Thirty-three of the 50 mini-screws were successful and received score 1, meaning they withstood the orthodontic forces until the treatment was finalized; one received score 2 because it was removed before the end of the treatment, but the treatment could be finalized; two mini-screws were active during a short time and 14 were lost prior to orthodontic regulation and given score 4. Success (score 1) or failure (scores 2–4) was not influenced by jaw or implant length or implant width as tested with chi-square test (level of significance $p < .05$ was never obtained). Anterior implants, positioned mesial to the canine root, showed statistically significant higher success than implants located in premolar or molar areas ($p < .05$) as indicated in Table 1. Respectively, 24 and 26 implants were loaded within 4 days or after 14 days of surgery. The maximal success score 1 was obtained by 14/24 early loaded implant versus 19/26 delayed loaded, but this was statistically significantly different. No significant relation was detected between implant success and the initial plaque or gingivitis score as shown in Tables 2 and 3. The forces applied to the mini-screws at the time of installation of the coil with a gauge (CORREX™, HAAG-STREIT AD, Bern, Switzerland). Forces were on average 138.6 g (SD 35.5; range 55–225). Table 4 shows the results of the questionnaire assessing encountered discomfort and general experience.

DISCUSSION

Thirty-three of all implants survived until the planned orthodontic correction was completed. The mean screw survival period was 31 days. This coincides with results described elsewhere.[10] Two implants even survived during 20 months of orthodontic treatment and remained stable after the present study was closed. A further three of the lost screws were sufficiently able to withstand orthodontic forces during a period of several months and were of significance in the overall orthodontic treatment. The classification as a failure does not always mean an absence of clinical success. Furthermore, a failed implant can be replaced, at relatively low costs and with low morbidity or patient's discomfort under local anesthesia. This is a great advantage compared to conventional osseointegrated implants or orthodontic bone anchors.

Some authors advocate more precise radiographic imaging techniques, such as computed tomography scan

TABLE 2 Distribution of Full-Mouth Plaque Index (PI) (Initially Scored Prior to Prophylaxis and Treatment) Related to Mini-Screw Success Score

Initial PI before prophylaxis (%)	1–2	3–4	Survived/Inserted
<20	18	11	18/29
+20–40	5	4	5/9
+40–80	11	1	11/12

TABLE 3 Distribution of Full-Mouth Gingivitis Index (GI) (Initially Scored Prior to Prophylaxis and Treatment) Related to Mini-Screw Success Score

Initial GI before prophylaxis (%)	1–2	3–4	Survived/Inserted
<20	28	16	28/44
+20–40	6	0	0/6
+40–80	0	0	0/0

analysis, in order to quantify the available space between the roots for mini-implants.[16] Because no complications such as tooth, pulp, or nerve damage occurred, and taking into consideration the radiation exposure and the cost to the patient, we do not recommend these sophisticated techniques. From a cost–benefit point of view, the treatment with mini-screws should be a simple technique, not requiring high speciality training in dental implantology.

Bone density contributes to the stability of the implant,[11] and therefore it is expected that mandibular implants are more stable than maxillary implants. This is not confirmed in this study, and the results show slightly the opposite although not statistically significant. This could be caused by the stronger bony fixation. Because the mini-screw is self-tapping and the site is only minimally prepared, this can be a risk for overheating because of friction. An implant placed in the anterior seems to be more successful to the posterior zone. This can be clarified by the fact that the implants are more easily to place in the anterior region at ergonomic point of view. More space and better view on the receptor site facilitate inclination of the pilot drill and the implant. Inclination is a very important factor which determines the quantity of alveolar and particularly cortical bone, surrounding the implant. The more bone contact and primary stability of the implant, the better the outcome,[17] and it is recommended that the surrounding bone between implant and adjacent periodontal ligament is at least 1 mm.[18] This enhances the stability of the implant which is favorable to withstand orthodontic forces. The periodontal ligament, alveolar bone, and root cement are capable to repair from placement trauma. Although root contact should not imply a necessary failure,[19] clinical experience learns that alveolar bone surrounding this implant is preferable to other anatomical structures. Furthermore, a proper inclination is primordial to avoid contact with dental roots or other anatomical structures which could result in patient discomfort or increase risks for inefficient usage or early failure of the implant. In the present clinical study, no irreversible damage to dental roots or neighboring anatomical structures occurred in this study.

TABLE 4 Patients' Opinions Regarding Treatment

Question	Yes	No
Were you skeptic before the mini-screw treatment?	8	13
Did you feel pain during treatment?	8	13
Did you feel pressure during treatment?	15	6
Was the treatment time too long?	2	19
Did you feel pain after the treatment?	10	11
Did you feel pressure after the treatment?	11	10
Did the mini-screw hinder you from speaking or chewing?	1	20
Is the mini-screw difficult to clean?	3	18
Did the mini-screw come up to your expectations?	18	3
Are you generally satisfied with the final result?	20	1
Would you undergo the same treatment if necessary?	19	2
Would you recommend the mini-screw treatment to others?	20	1

The implant size in relation to success has been investigated in this study. In general, the longest and widest possible implant is chosen in order to obtain a firm primary stability.[14] On the other hand, the risk to damage anatomic structures like dental roots increases by a larger size. Also, the bony support may be jeopardized when the distance from screw to implant is minimal. These two arguments could explain why wider screws show a trend for fewer efficacies.

The mini-screws offer the possibility to be loaded within 1–2 weeks. In this study, 19/26 of the immediately loaded implants were able to survive during the entire orthodontic treatment. It has been shown histologically that a layer of fibrous tissue was interposed between the mini-screws at the bone–implant contacts, when the load was placed prematurely.[20] This fibrous layer could prevent osseointegration and compromise the secondary stability of the implant, but the mechanical retention seems sufficient to offer enough clinical stability to sustain orthodontic forces. Currently, there are no studies available where mini-screw success had been

related to the exerted forces. Forces of 300 g were already described to intrude maxillary molars.[21] In our study, the forces, measuring tension, or stress, initially applied by the orthodontic coils were measured with a Richmond gauge (CORREX, HAAG-STREIT AD). Peak forces of over 200 g were achieved at the time of activation of the screw into the orthodontic appliance without loss of the mini-implant. The average forces applied to the early lost implants were even lower (103.9 g) than those of the successful implants (152.6 g). Whether this is because of less initial stability or fixation, or that to the fact that a higher load-stimulated bone remains undecided from this study, is an interesting aspect to be raised in future studies.

In each orthodontic treatment, periodontal conditions must be taken in consideration. A histological study[22] emphasizes that a healthy periodontium is absolutely necessary to achieve perfect orthodontic tooth displacements. Bad oral hygiene and orthodontic treatment are an unfavorable combination and could lead to accelerated periodontal breakdown. Strict plaque control reflecting in low bleeding scores was a selection criterion in this study, and if necessary, periodontal prophylaxis was carried out preceding the placement of the implants. All patients were also professionally maintained during the study which can explain why there is no clear relationship between success and periodontal condition.

When patients' opinions were evaluated, general satisfaction was observed, although one in every three patients complained of postoperative pain and a feeling of pressure in the bone during screw placement. The feeling of pain is a subjective parameter, but it is recommendable that the patient be better informed about the occurrence of some minor postoperative discomfort. In this study, medication for pain was not routinely prescribed but left to the discretion of the patient. This could explain the negative outcome and can probably be avoided by better communication and prescription of painkillers. The biggest majority of the patients would recommend orthodontic anchorage by means of miniscrews and found the treatment feasible and acceptable.

CONCLUSION

The results of this pilot study reveal that mini-screws are a safe, inexpensive, patient-friendly, and easily applicable alternative to extraoral orthodontic anchorage. In 68% of the cases, the screws were functional to obtain the orthodontic correction they were aiming for, and the risk for irreversible damage to teeth or anatomical structures was neglectable. Nevertheless, patients should be informed that in one out of three cases, retreatment during orthodontics may be needed. The assumption that the treatment is painless and easy is not sustained by the results of the patients' opinions as reflected by the questionnaires. This negative experience is, however, overruled by the advantages of having the anchorage device intraorally.

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