Clinical use of miniscrew implants as orthodontic anchorage: Success rates and postoperative discomfort

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Introduction: In this study, we evaluated the clinical usefulness of miniscrews as orthodontic anchorage. We examined their success rates, analyzed factors associated with their stability, and evaluated patients' postoperative pain and discomfort with a retrospective questionnaire. Methods: Seventy-five patients, 116 titanium screws of 2 types, and 38 miniplates were retrospectively examined. Each patient was given a questionnaire that included a visual analog scale to indicate discomfort after implantation. Results: The success rate for each type of implant was greater than 80%. The analysis of 79 miniscrews with a 1.3-mm diameter showed no significant correlations between success rate and these variables: age, sex, mandibular plane angle, anteroposterior jaw-base relationship, control of periodontitis, temporomandibular disorder symptoms, loading, and screw length. Most patients receiving titanium screws or miniplates with mucoperiosteal-flap surgery reported pain, but half of the patients receiving miniscrews without flap surgery did not report feeling pain at any time after placement. In addition, patients with miniscrews reported minimal discomfort due to swelling, speech difficulty, and difficulty in chewing. Conclusions: Miniscrews placed without flap surgery have high success rates with less pain and discomfort after surgery than miniscrews placed with flap surgery or miniplates placed with either procedure. (Am J Orthod Dentofacial Orthop 2007; 131:9-15)
associated with their stability, and evaluated patients’
postoperative pain and discomfort caused by implanta-
tion with a retrospective questionnaire.

MATERIAL AND METHODS

Our subjects were 75 patients with malocclusions
(12 male, 63 female; mean age, 21.8 years; SD, 8.2
years) who had surgery at Okayama University Hospi-
tal to place a skeletal anchorage for edgewise treatment
between November 2000 and March 2004. Before
implantation, the advantages and disadvantages were
explained to each patient and his or her parents when an
implant anchor was considered desirable for orthodon-
tic treatment. Two kinds of titanium screws with
different diameters and lengths were used: type A
(Inter-maxillary fixation screw, Keisei Medical Indus-
trial, Tokyo, Japan): diameter, 2.0 or 2.3 mm; length, 7
or 11 mm; screw head, 3 mm; and type B (AbsoAnchor,
Dentos, Daegu, Korea): diameter, 1.3 mm; length, 6, 7,
8, 10, and 12 mm; screw head, 3 mm. Miniplates with
2 or 3 screws (SAS system [Dentsply-Sankin, Tokyo,
Japan]; diameter, 2.0 mm; length, 5 mm) were also
used for skeletal anchorage (Fig 1).

The miniplates were placed under local anesthesia
by senior oral surgeons at the Department of Oral and
Maxillofacial Surgery, Okayama University Hospital in
Japan. First, a mucoperiosteal incision was made at
the site where emergence of the anchor was desir-
able. The mucoperiosteal flap was then reflected to
expose the cortical bone. The miniplate was adjusted
to fit the contour of the bone surface, and screw holes
were made by using a 1.5-mm twist drill with contin-
uous normal saline-solution irrigation. The plates were
then fixed by 2 or 3 monocortical miniscrews by using
a self-tapping method. The head of miniplate was
exposed to the oral cavity through the incision. The

Fig 1. Implants used as orthodontic anchorage. A, Type A titanium screws, 2.0-mm in diameter and
7-mm in length, and 2.3-mm in diameter and 11-mm in length; B, type B titanium screw, 1.3-mm in
diameter and 8-mm in length; C, miniplate with screws, 2 mm in diameter and 5 mm in length;
D, clinical use of type B screw.
mucoperiosteal incision was sutured with 3-0 silk. The sutures were removed 7 to 10 days after surgery.

Type A screws were placed by the same senior oral surgeons in the same manner as miniplates. Under local anesthesia, the mucoperiosteal flap was reflected to expose the cortical bone. The screw holes were made by using a 1.6-mm twist drill with continuous normal saline-solution irrigation. The screw head was adjusted at least 2 mm above the mucosa and exposed to the oral cavity through the incision. The mucoperiosteal incision was sutured, and the sutures were removed 7 to 10 days after surgery.

Type B screws were placed under local anesthesia by an orthodontist (S.K.). No mucoperiosteal incision or flap was made, and the screw holes were made by a 1.0-mm round bar and twist drill at 500 rpm with continuous normal saline-solution irrigation. The 1.3-mm screws were then placed through the attached gingiva by using a self-tapping method with continuous irrigation. The screw was inserted 5 or 6 mm into the alveolar bone, and the screw head was adjusted at least 2 mm above the mucosa. (Fig 1D). After the placement surgery, the positions of the screws were checked with dental radiographs.

The orthodontic appliances were not adjusted at the implantation appointment. Loading of the miniplates and the type A screws began 4 to 12 weeks after placement surgery, whereas that of the type B screws began 0 to 12 weeks after surgery. The orthodontic load was applied by elastic chain or nickel-titanium closing coil springs, estimated between 50 and 200 g. If the orthodontic force could be applied to the skeletal anchorage for 1 year (or until completion of the orthodontic treatment), we recorded the skeletal anchorage as a success.

Each patient received a retrospective questionnaire with a 100-point visual analog scale (VAS) concerning discomfort caused by the implant surgery, not by the adjustment of the orthodontic appliances. They were asked whether they experienced any of the following forms of discomfort after implantation: pain (time course and intensity), swelling, difficulty in chewing, speech difficulty, and difficulty in toothbrushing. The VAS was a 100-mm line with anchors at each end of the line that read “no pain (or discomfort)” (0 mm) and “pain (or discomfort) as much as it could be” (100 mm). Those who experienced pain were asked when it occurred: immediately after implantation, after 1 hour, at 12 hours, and from 1 to 14 days.

**Statistical analysis**

The chi-square or the Fisher exact probability test was used to examine the correlation between the success rates and types of implant anchor for the 154 implant anchors. Those tests were also used to examine the correlations between the distribution of patients reporting pain and the types of implant anchor. Analysis of variance and the Fisher protected least-significant difference were used to compare the discomfort of each implant anchor in the 75 subjects with 154 implant anchors. A nonparametric correlation analysis between the variables of discomfort was made by using the Spearman rank correlation methods. The chi-square or the Fisher exact probability test was used to examine the correlation between the success rates and the classifications of each variable for the 79 implants of screw B. Any probability of $P > .05$ was considered insignificant. These analyses were made with statistical analysis software (StatView, SPSS, Chicago, Ill).

**RESULTS**

There was no significant difference in the success rates between types A and B screws or between miniplates and type A or B screws. Each type of implant had a high success rate over 80% (Table I). Contacts between screws and roots were not observed in radiographs.

In the analysis of the 79 type B screws, there were no correlations between the success rate and any of the following variables: age, sex, mandibular plane angle, anteroposterior jaw-based relationship, control of periodontitis, temporomandibular disorder symptoms, start of loading, amount of loading, and screw length. However, the type B screws for intrusion had a significantly lower success rate than that for other orthodontic indications (Tables II and III). In addition, use in the molar area had a significantly lower success rate than in the premolar area when the type B screws were placed buccally.

Type A screws and miniplates showed similar time course distributions in patients reporting pain (Fig 2). Most patients reported pain 1 hour after placement surgery, approximately 95% of type A screws and 100% of miniplates, and most patients required pain medication. However, 1 hour after surgery, only half of

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<th>Clinical variable</th>
<th>Type A (%)</th>
<th>Type B (%)</th>
<th>Miniplate (%)</th>
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<td>Success rate</td>
<td>81.1</td>
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the patients with type B screws reported pain, and the frequency dropped to 10% at day 1. At day 5, more than half of patients with type A screws or miniplates continued to report pain. After day 7, no patient with a type B screws reported pain, whereas approximately 10% of the patients with type A screws or miniplates still reported pain more than 14 days after surgery. Significant differences in the numbers of patients reporting pain were observed between type A and type B screws on day 0 to day 9, and miniplates on day 0 to day 14 ($P < .05$). Half of the patients with type B screws did not feel pain and used no pain medication at any time after surgery.

The intensity of pain reported by the patients showed a similar time course as the distribution of patients reporting pain (Fig 3). The VAS assessments peaked 1 hour after surgery when the average pain intensity reached 65.7 for type A screws, 66.4 for miniplates, and 19.5 for type B screws. There was a significant difference in the mean scores, with VAS assessments of type B screws significantly lower than those of miniplates and type A screws. The difference in scores between miniplates or types A and B screws immediately after surgery to 7 days after surgery was statistically significant ($P < .05$).

There were significant differences in the discomfort of swelling, speech difficulty, and difficulty in chewing after placement surgery between types A and B screws, and between miniplates and type B screws ($P < .001$) (Fig 4). Difficulty in speech and chewing were correlated with intensity of swelling ($P < .001$). However, there was no significant difference in difficulty in toothbrushing between types A and B screws, or between miniplates and type A or B screws.

**DISCUSSION**

Miniplates and titanium screws of more than 1.5 mm in diameter were used as orthodontic anchorages.\textsuperscript{5-10,14,15} In this study, the success rates of miniplates and type A screws were more than 80%. We previously reported success rates of 96.4% for miniplates, 83.9% for 1.5-mm screws, and 85.0% for 2.3-mm screws.\textsuperscript{14} Cheng et al\textsuperscript{15} reported an 89% success rate with 140 screws measuring 2.0 mm in diameter. Recently, miniscrews less than 1.5 mm in diameter have been used for various methods of tooth movement.\textsuperscript{11-13} We used 79 small titanium screws measuring 1.3 mm in diameter (type B), and our success rate was 88.6%. Therefore, it is suggested that miniscrews are as stable as miniplates or long, large-diameter screws.

Type B screws showed no correlations between the success rate and several clinical variables: age, sex,
mandibular plane angle, and anteroposterior jaw-based relationship. The screw length of type B had no correlation to the success rate. We selected the screw length according to the thickness of the oral mucosa and allowed 5 to 6 mm of bone support. For instance, we used a 10-mm screw if the palatal mucosa was 4 mm thick. Therefore, the screw lengths in this study might not be related to the success rate, because they did not correspond to the length implanted into the bone. Type B screws could resist a load of 200 g for en-masse tooth movement even if they were inserted only 5 mm into the bone. Miniscrews, which have short lengths and small diameters, are considered unlikely to touch the root if they are placed in a tooth-bearing area, and unlikely to invade the maxillary sinus. In addition, miniscrews are also considered to be less surgically invasive than long, large-diameter screws. Therefore, miniscrews are more useful than miniplates or long, large-diameter screws in clinical applications.

Our histological study indicated that small titanium screws can function as rigid osseous anchorage against orthodontic loads with a minimal healing period.22,23 In this study, the timing of loading was not related to the success rate as we had shown in our previous report.14 Type B screws with immediate loading had a high success rate of 89.8%. In addition, Romanos et al22 showed that immediate loading increased the ossification of the alveolar bone around the implant. Therefore, immediate loading might have contributed to the good prognosis of miniscrew implants.

The use of type B screws for intrusion at the posterior maxilla and mandible showed a significantly lower success rate than that for other orthodontic indications. In the maxilla, it might be difficult to obtain sufficient mechanical interdigitation between the screws and the alveolar bone, because cortical bone is thinner than the mandible. Our previous study showed that
maxillary implants had less bone-implant contact than those of mandibular in dogs. In addition, oral hygiene control is sometimes poor in the posterior maxilla, and the risk of peri-implant inflammation is higher than that in the anterior region. For intrusion of the maxillary molars, we recommend placing the screws outside the buccal alveolar area. Titanium screws placed in the zygomatic process are useful to intrude maxillary molars. In addition, the palate is a suitable area to place miniscrews for intruding maxillary molars, because the palate has sufficient cortical bone and attached gingiva. In our study, type B screws in the palatal molar area had a higher success rate than those in the buccal molar area.

Cheng et al also reported that screws in the posterior mandible had a lower success rate. In our animal study, all implant failures occurred in the mandible. The reason remains unclear; however, several possibilities are speculated. We placed the screws between the roots of the first and second molars through the attached gingiva when intrusion of molars was required, but this was a narrow site, and the surgical procedure was technically difficult. In addition, the posterior mandible has less attached gingiva and a narrow oral vestibule; therefore, oral hygiene around the screws tends to be worse, and the screws are more susceptible to infection. Thus, the reason for the lower success rate in the mandible might be related to the surgical difficulty caused by the anatomical structure of the mandible.

Pain during orthodontic treatment is a patient’s major concern. Half of the patients with type B screws did not complain of pain and did not need pain medication at any time after surgery. In our previous study, most patients receiving 1.5-mm screws without flap surgery reported neither swelling nor pain. We believe that flap reflection is closely related to pain caused by the surgical procedure. In a previous study, 50% of the patients who received periodontal-flap surgery reported severe or moderate pain after the surgical procedure. Curtis et al showed that mucogingival surgery was significantly related to pain and was 3.5 times more likely to cause pain than osseous surgery and 6 times more likely than plastic soft-tissue surgery. A clinical trial to evaluate the influence of the incision and the reflection of a flap on pain after removal of the mandibular third molars indicated that the nonsurgical approach was effective in reducing pain and discomfort after extractions. In addition, the flapless surgical technique to place the dental implant causes less pain and discomfort for patients. Therefore, the placement of screws without an incision or flap surgery could reduce both the intensity and the duration of pain after surgery, and flap surgery should be avoided to reduce the patient’s pain after the placement procedure.

In most orthodontic treatments, pain generally increases with time, according to measurements at 4 and 24 hours, and then decreases to normal levels of sensation 7 days after treatment. A pain assessment of 40 to 50 on the 100-point VAS scale was shown 1 day after orthodontic treatment. In this study, we asked patients to report the pain caused by the implants, and VAS assessments for the type B screws peaked 1 hour after surgery when the average pain intensity reached 19.5. It is suggested that pain caused by the type B screw might be less than that caused by orthodontic tooth movement. In addition, when the orthodontic treatment is finished, miniscrews can be removed under topical anesthesia only and do not require sutures or postremoval medications. Therefore, miniscrews placed without flap surgery are more comfortable for the patient because of the minimal surgical invasion, and they provide suitable orthodontic anchorage.

There were significant differences in the discomfort of swelling, speech difficulty, and chewing difficulty after placement surgery between types A and B screws, and between miniplates and type B screws. Type B screws are more comfortable than type A screws or miniplates for patients during orthodontic treatment. Speech and chewing difficulties might be correlated with the intensity of swelling. Miniplates and long screws placed through movable soft tissue sometimes cause swelling adjacent to the implantation site after flap surgery or infection during treatment. In contrast, type B screws placed at the attached gingiva without incision are less likely to develop infection and inflammation. Patents with type B screws might report slight swelling during treatment. In addition, no bleeding was observed immediately after surgery when type B screws were placed at the attached gingiva. Therefore, we believe that miniscrews placed without flap surgery are more comfortable for patients.

**CONCLUSIONS**

Miniscrews had a high success rate of approximately 90%—the same as miniplates and large titanium screws, and they provided sufficient anchorage immediately after placement surgery for any orthodontic tooth movement. In addition, miniscrews placed without a mucoperiosteal incision or flap surgery significantly reduced the patient’s pain and discomfort after implantation. Miniscrews have suitable characteristics as orthodontic anchorage.
REFERENCES


