Forty Consecutive Ramus Bone Screws Used to Correct Horizontally Impacted Mandibular Molars

Abstract

Failure of temporary anchorage devices (TADs) is a serious limitation when treating complex problems like horizontal impactions of mandibular molars, because there are few other viable options. From a biomechanics perspective, the anterior ramus of the mandible is an ideal location for a TAD. However, this area appears to be a high risk site because it is covered with thick, mobile soft tissue.

***Objective**: Assess the failure rate and efficacy of ramus bone screws used as anchorage to upright horizontal impactions of mandibular molars within four months.*

***Materials and Methods**: The sample (n = 37) was thirty-seven consecutive patients (20 males, 17 females, mean age 18±6 yr) with horizontal impactions distal to the functioning lower arch. Three patients had bilateral horizontal impactions, for a total of 40 consecutive ramus bone screws. The crowns of the impactions were uncovered and bone was removed down to the cementoenamel junction, if needed. All screws were placed perpendicular to the ascending ramus, about 5 mm superior to the occlusal plane of the mandible. For oral hygiene access, the head of the screw was at least 5 mm above the soft tissue. The load applied to upright the molars ranged from 2-4 oz (57 g-113 g, 56 cN-112 cN).*

***Results**: Ramus screw anchorage was very effective for uprighting horizontal impactions. Two of the 40 screws failed (2/40 = 5%) due to soft tissue hypertrophy that covered the head of the screw, but none were loose relative to supporting bone. Both failing screws were repositioned with additional soft tissue clearance, and then they were then successful for the purpose intended.*

***Conclusion**: Ramus screws were highly successful (38/40 = 95%) as anchorage units to upright horizontal impactions in the posterior mandible. When the two failed screws were repositioned, they were successful as planned, so the overall success rate for ramus screw anchorage was 100%. (Int J Orthod Implantol 2016;41:60-72)*

Key words:
Horizontally impacted second molars, molar up-righting, ramus screws, TAD failure rate, soft tissue hypertrophy, TAD repositioning

Introduction

Horizontally impacted mandibular molars are complex problems that are refractory to routine orthodontic treatment. An efficient treatment strategy required the development of anchorage devices that were suitable for challenging intraoral sites outside the alveolar process. Roberts et al.[1] utilized osseointegrated implants as extra-alveolar (*E-A*) temporary anchorage devices (*TADs*) for closing edentulous spaces in mandibular arch. These retromolar devices were reliable and efficient, but the site for the osseointegrated fixtures was in the

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same location as horizontally impacted molars, so they were unsuitable anchorage for their recovery. Subsequently, Kanomi[2] and others[3,4] introduced multiple types of titanium alloy (*Ti*) miniscrews that were placed in the alveolar process between the roots of teeth. These interradicular (*I-R*) devices were not well suited for complex problems like horizontal impactions, and they often had a high failure rate particularly in the posterior mandible (*Table I*). Furthermore, the I-R TADs had other limitations[5-8] including damaging the roots of teeth, were not rigid (*moved within the bone*), and often interfered with the path of tooth movement, so they were not suitable for managing deep horizontal impactions.

Realizing that the first two generations of TADs (*retromolar and I-R*) lacked the versatility to manage horizontal impactions. Chang et al.[5] expanded the E-A TAD concept by developing a 2 mm diameter stainless steel (*SS*) bone screw (*Fig. 1*) that was suitable for dense cortical bone sites, such as the mandibular buccal shelf (*MBS*). The MBS bone screw

■ *Fig. 1: A 2x14-mm stainless steel bone screw was designed to be inserted in the ramus as a self-drilling fixture.*

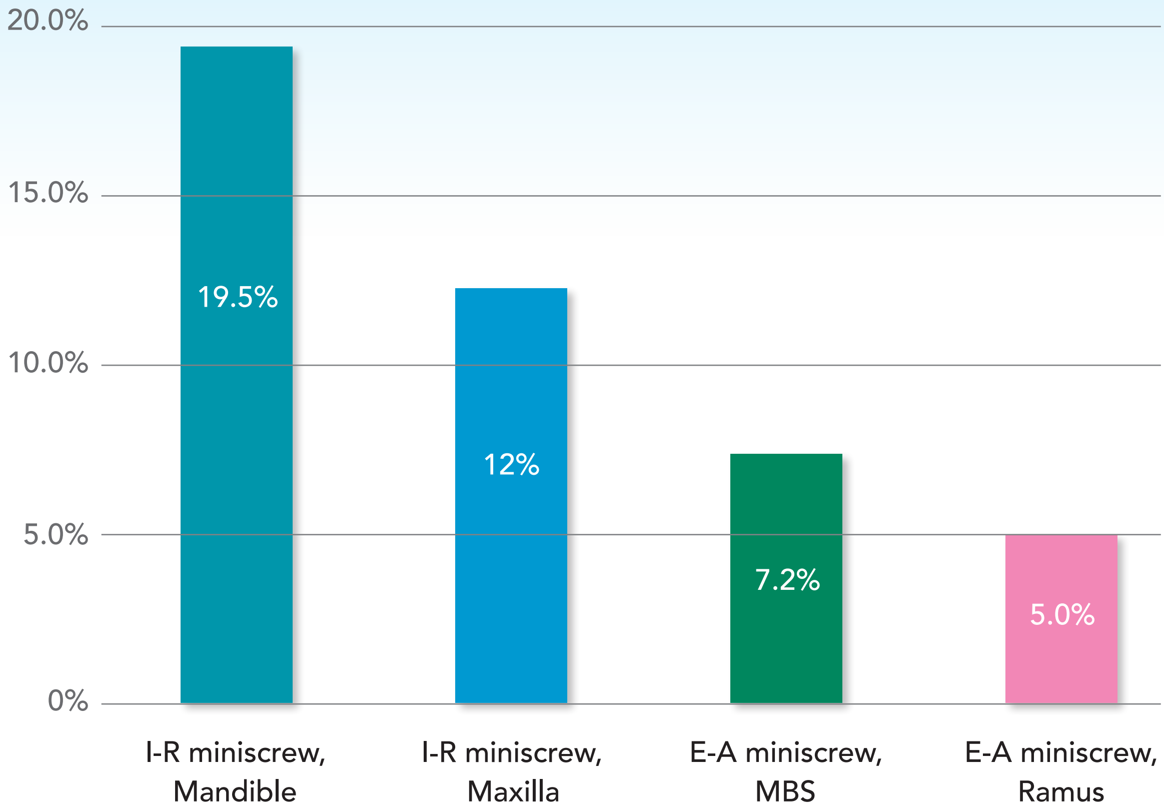


Table 1:
The failure rates for four types of TADs are illustrated in a bar graph. Interradicular (I-R) miniscrews are placed in the alveolar process between the roots of teeth. Extra-alveolar (E-A) are place outside the alveolar process. I-R miniscrew in the mandible (blue) and the maxilla (royal blue) are compared to E-A (extra-alveolar) bone screws in the MBS (mandibular buccal shelf, green) and anterior ramus of the mandible (red).

was placed lateral to the first and second molars, so it did not interfere with the retromolar location of horizontal impactions, or the path of tooth movement within the alveolar process. However, active mechanics to recover horizontal impactions with MBS bone screws were complex and difficult to control. To better address the mechanical problems, bone screws were needed in the anterior ramus of the mandible to provide a more superior and posterior direction of traction, along the plane of the impaction. The major concern from the onset was the risk of failure when using TADs in a challenging intraoral site like the anterior ramus of the mandible. A detailed review of TAD failure was in order to design a reliable bone screw for recovering horizontal molar impactions.

Retromolar osseointegrated implants,[1] the original E-A TADs, have about the same failure rate as other osseointegrated fixtures (<5%), but the risk of failure for I-R miniscrews is much greater, which may relate to their highly variable shape, diameter (*1.0-2.3 mm*), and length (*4-21 mm*).[6-14] Since the failure rate for many I-R devices is relatively high, many authors report the clinical experience as a "*success rate*" from 57-95%, with an average of about 84%.[15-17] E-A SS miniscrews are used in the MBS and infrazygomatic crest (*IZC*) for retracting or protracting individual teeth or entire arches, to correct a wide variety of malocclusions.[18,19] A large study of 1,680 consecutive MBS miniscrews reported a failure rate of only 7.2%,[5] which is considerably lower than for I-R miniscrews in the mandible (*19.3%*) or the maxilla (*12.0%*) (*Table 1*).[20-21]

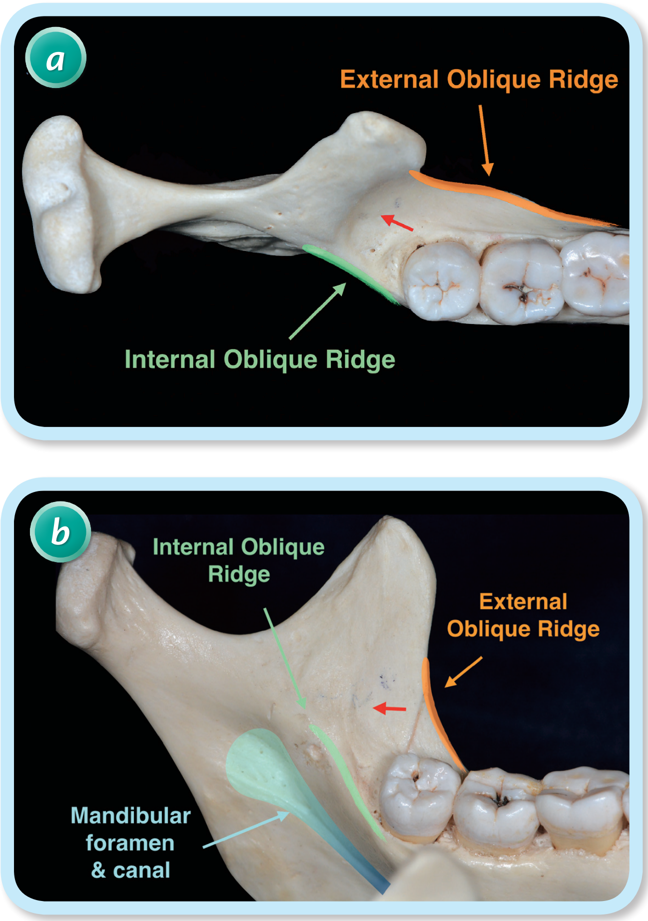
Failure of multiple osseointegrated implants in the maxilla of individual patients are associated with parafunction and psychologic factors,[22] but those parameters have not been systematically studied relative to TADs. However, Chang et al.[5] did note bilateral failures of MBS bone screws in multiple patients, suggesting that some patients are predisposed to TAD failure. Miniscrew failure may be due to a loss of stability, or to soft tissue inflammation, so primary stability is the critical factor for clinical success.[23-25] The latter is enhanced by a larger diameter screw, smaller diameter pilot hole, and thicker cortical bone.[23-26] Furthermore, the self-drilling protocol can also play a role.[27,28] Screw design studies show a >70% success rate for I-R miniscrews with a diameter of ≥1.2 mm, and multiple studies show that success is directly related to the screw length.[12-14,29] However, the probability of root damage is increased when a wider diameter I-R miniscrew screw is used.[29] A recent review[30] indicated that cortical bone thickness appears to be the most important factor for primary stability. The overall experience with I-R miniscrews indicated they were high risk TADs with little potential for managing complex problems like horizontal impactions in the posterior mandible.

Despite the obvious mechanical advantage of a ramus screw for uprighting a horizontally impacted molar, there are numerous concerns about this region as an E-A TAD site: 1. highly mobile alveolar mucosa, 2. relatively thick layer of unattached soft tissue, 3. underlying layer of active muscle some of which is attached to bone, and 4. difficult area for maintaining oral hygiene to control soft tissue hyperplasia.[31] A 2x14 mm SS screw was designed as the best fit for the anatomical features of the anterior ramus region (*Fig. 1*). The objective for testing this screw was to assess its failure for any reason, in serving as adequate anchorage to recover a horizontal impaction(*s*). The null hypothesis is that ramus screws will have a high failure rate and low efficiency in recovering horizontal impactions of mandibular molars.

Material and Methods

In this study, the ramus screws were inserted in 37 consecutive patients (*20 males, 17 females, mean age 18±6 yr*), presenting for treatment of horizontally impacted mandibular molars. Three of the patients had bilateral impactions, so a total of 40 stainless steel, self-drilling miniscrews (*2x14 mm, Newton's A Ltd, Hsinchu City, Taiwan*) were installed in the anterior ramus to upright the uncovered impactions. All the patients were treated over a three year period (*2013-15*) in a single private practice by the same orthodontist. The ramus screws were installed under local anesthesia, without flap elevation or pilot drilling.

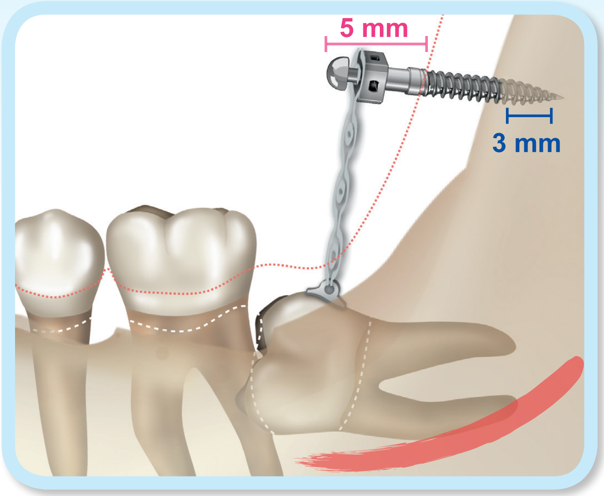
The selection of the anatomical site and the screw design (*Fig. 1*) was based on a careful study of anatomy of the anterior ramus (*Figs. 2 and 3*). The optimal site for a direct line of traction without occlusal interference was midway between the external and internal oblique ridges (*Fig. 4*) of the ascending ramus, about 5-8 mm above the occlusal plane (*Fig. 5*). A relatively long (*14 mm*) SS miniscrew was selected because of the need to penetrate thick unkeratinized mucosa, with an underlying layer of masticatory muscle. For hygiene access, the TADs were screwed in until the head of the TAD was ~5 mm above the level of the soft tissue (*Fig. 5*).



■ *Fig. 2:*
Anatomy of the mandibular ramus is viewed from the superior (a) and mesial (b) perspective. The insertion site for a ramus screw (red arrows) is between external and internal oblique ridges, about 5-8 mm superior to the occlusal plane. From the occlusal perspective, note the relatively smooth, broad area between the internal and external oblique ridges (a). In the lateral view (b) note that the insertion point for the bone screw (red arrow) is distant from the mandibular foramen and inferior alveolar canal.

■ *Fig. 3:*
After administering local anesthesia, the clinician locates the external oblique ridge with the left thumb, and then marks the site for the ramus screw by sounding through the soft tissue to bone with a sharp explorer.

■ *Fig. 4:*
The insertion site for the bone screw is about 5-8 mm above the mandibular occlusal plane.



■ *Fig. 5:*
Left: after TAD placement, the screw head is about 5 mm above the soft tissue.
Right: The average bone engagement for a ramus screw is ~3 mm.

All miniscrews were immediately loaded using pre-stretched elastomeric modules (*power chains*)[32-34] attached to the button or eyelet bonded on the impacted teeth (*Fig. 5*). The patients were instructed in oral hygiene procedures to control soft tissue inflammation. For reactivation at monthly intervals, the traction force was increased by advancing one loop on the elastic chain and cutting it off every 4 weeks (*Figs. 6 & 10*). The stability of the ramus screws was regularly hand tested at 4 week intervals for 4 months, which was the maximum duration of the molar uprighting phase of treatment. At 5 months the previously impacted molars were bonded with a routine buccal bracket.

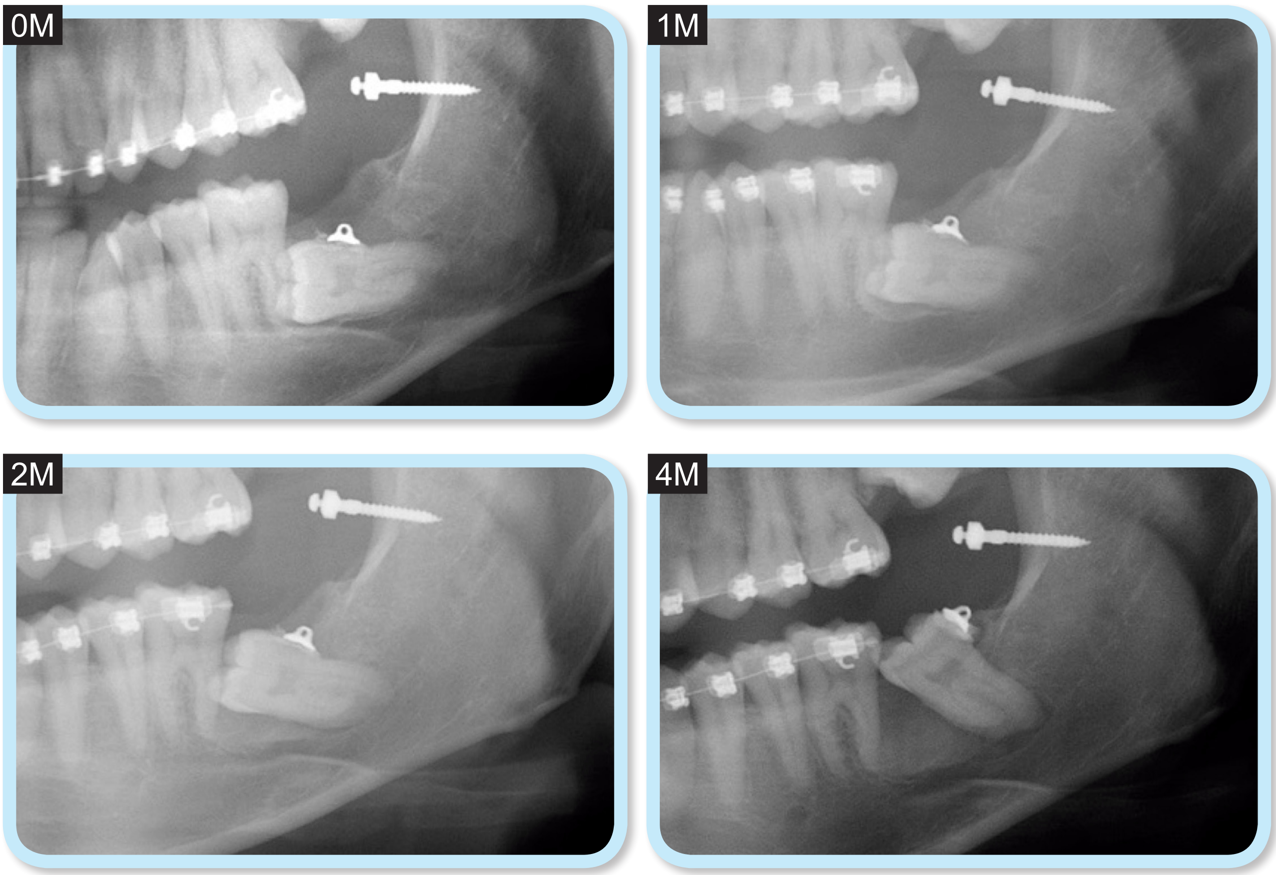
Results

Only 2 out of 40 ramus screws (5%) failed to serve as adequate anchorage for uprighting the horizontal impaction. Neither failed screws were loose, but there was soft tissue overgrowth and severe inflammation around the TAD head. The failures occurred in different patients; one was on the right side of a 12 year-old boy and the other was on the left side of a 13 year-old girl. Both failed screws were removed, the hypertrophic soft tissue was removed, the bone screw was cleaned with alcohol, and then repositioned in an adjacent location, leaving at least 5 mm exposure for the screw head. Both of the initial failures were then clinically successful, so all 40 horizontally impacted molars were recovered and aligned except for one impaction, that had no bone on the distal surface of the root when it was uncovered.

Discussion

Extra-alveolar (*E-A*) bone screws are very effective for managing a variety of malocclusions including deeply impacted teeth.[35] The most common impacted tooth is the third molar, followed by the maxillary canine and mandibular second molars.[36] The current study of 37 patients with a total of 40 horizontal molar impactions appears to be the largest orthodontic sample of horizontal mandibular molar impactions reported. These dental anomalies are complex problems that are difficult to treat to an optimal outcome. The most problematic aspect of the treatment is the initial uprighting, which this study demonstrates can be routinely accomplished with ramus screw anchorage in 4 months or less (*Fig. 6*).

It is usually desirable to recover horizontally impacted mandibular second molars. Impacted third molars may also be valuable dental units if the adjacent first or second molars are compromised or missing. Uprighting horizontally impacted third molars prior to extraction may be a wise measure to avoid damaging the second molar and its periodontium and inferior alveolar nerve during a surgical extraction procedure. This approach may be wise, even if no other orthodontic treatment is needed.



■ *Fig. 6:*

Panoramic films were exposed immediately after surgery (0M), as well as one (1M), two (2M) and four (4M) months later. The horizontally impacted second molar was up-righted with 4 months of traction, and a routine molar tube was bonded one month later.

Ramus as a TAD Site

An efficient, yet simple mechanism is required to recover deeply impacted or mesially tipped molars. Lin[37] reviewed six different methods for recovering deeply impacted molars, and concluded that the most reliable and efficient approach was to surgically expose the deeply impacted molars and upright them with traction via a ramus bone screw.[38,39] The current study validates that concept.

2x14 mm Screws

Previous studies with mandibular buccal shelf bone screws,[1,6,19] utilized 2x12 mm stainless steel screws (SS), because soft tissue was less than 3 mm thick. A 12 mm screw length was adequate to leave ~5 mm of clearance between soft tissue and the head of the screw after installation (*Figs. 5 & 7*). On the other hand, a ramus screw must penetrate much thicker soft tissue before engaging the dense cortical bone of the mandible. Thus, a 14 mm screw is necessary to provide at least 5 mm of soft tissue clearance, after the bone has been penetrated 3 mm or more (*Fig. 8*).[40]

Complications

The anatomical structure near the ramus, presenting the most serious risk for complications, is the neurovascular bundle in the inferior alveolar (*mandibular*) canal (*Fig. 2b*). Under normal circumstances, the ramus TAD site is about 15 to 20 mm away from the neurovascular bundle. Once the screws are inserted, postoperative panoramic films revealed that the screw tip may be within 5 to 8 mm of the mandibular canal (*Figs. 7 - 9*). Fig. 10 is a series

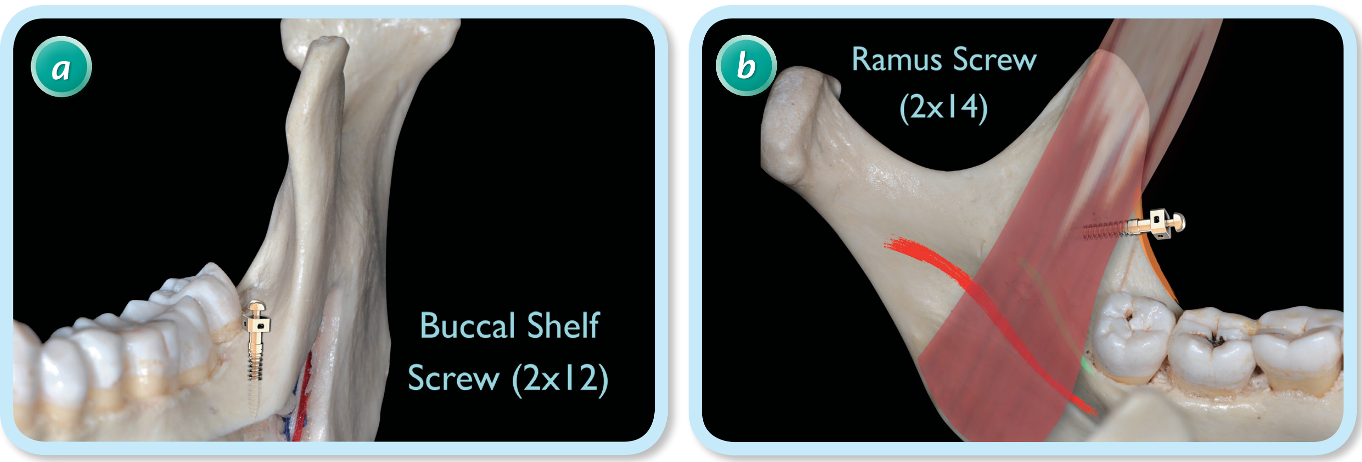


Fig. 7:

The insertion sites for E-A bone screws are compared.

a. A 2x12 mm screw is well secured in the bone (at least 3 mm) of the mandibular buccal shelf and there is still adequate clearance (~5 mm) above the soft tissue for hygienic maintenance.

b. The ramus screw must penetrate much thicker soft tissue to engage bone so a 2x14 mm SS screw is required.

Fig. 8:
The muscle in the retromolar area is composed of the traversing fibers of the medial pterygoid (a) and the anterior fibers of the temporals that are inserting into the ramus surface (b).

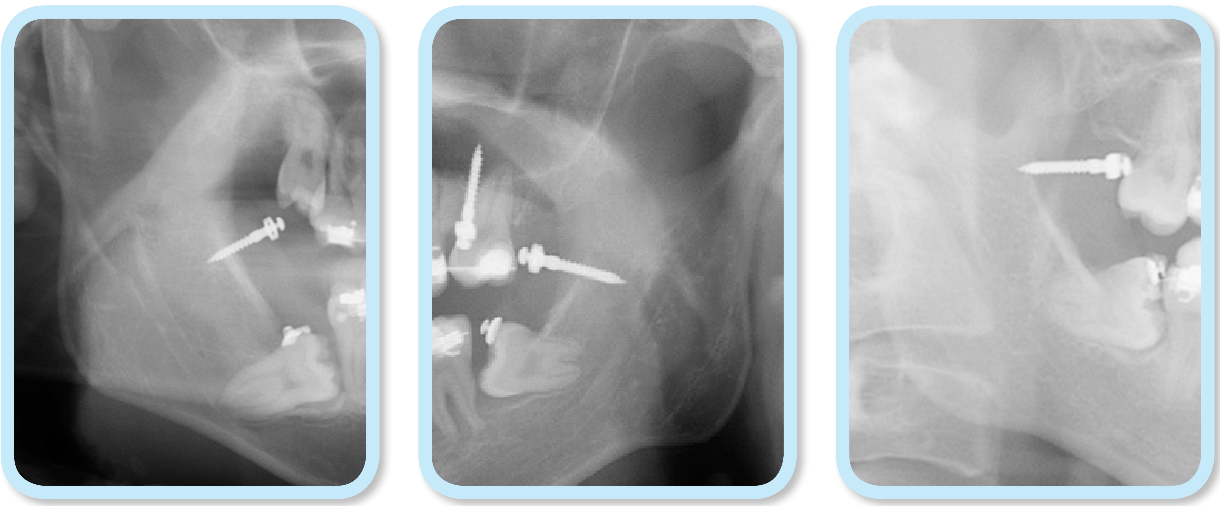


Fig. 9:
Panoramic films was taken immediately after 3 ramus screw insertions to evaluate the angulation of the screws, and estimate their proximity to the neurovascular bundle. None of the screws were closer than 5 mm to the inferior alveolar canal.

of drawings that illustrate the details for utilizing a ramus screw to upright a horizontally impacted molar. If a clinician carefully follows the detailed instructions provided, the risk of complications is minimal.

Screw Fractures in the Absence of Pre-drilling

Fracture is a significant risk for small (<2 *mm diameter*), brittle screws (*Titanium or Titanium alloy*) inserted into dense cortical bone with a self drilling technique.[41] A fractured screw is worrisome for the patient, may result in injury of adjacent tissue, or block the desired site for a TAD. Risk of screw fracture is decreased by increasing the diameter of the screw to at least 2 mm, using a tougher material such as stainless steel (SS), and drilling a pilot hole for the screw. The latter is not practical because of the thick soft tissue covering the bone, but using 2 mm diameter screws made of SS is a practical approach for decreasing fracture risk. On the contrary, increasing the length of a screw to 14 mm renders it more susceptible to a flexure-related fracture. All things considered, the 2x14 mm SS bone screw appears well suited as a ramus TAD, because to date none of the screws have fractured.

Ramus Screw Failure

Based on the previous experience with buccal shelf bone screws,[5] it's surprising that none of the ramus screws loosened during 4 months of traction. Only 2 of 40 screws failed to serve as adequate anchorage for uprighting molars, but those problems were because of soft tissue hyperplasia in adolescents with relatively poor oral hygiene. Both patients with the initial failures were successfully treated by removing the screws, resecting the hyperplastic tissue, and replacing it in an adjacent location. From these results it is clear that the success of ramus screws depends on appropriate hygiene measures. So it is very important to provide hygiene instructions and monitor soft tissue inflammation at each appointment.[31]

Sample Size and Inclusion Criteria

In collecting a group of patients to assess a clinical problem, it is important to avoid sampling bias. The patients selected may be a random or inclusive sample of all patients meeting the inclusion criteria within a given time frame.[42,43] The current study is an inclusive sample of patients with a relatively rare condition, that was treated with 40 ramus bone screws in 37 patients, over a 3 year time frame. One patient was rejected because the impacted molar was periodontally compromised. Randomization is inappropriate for such a small number of patients. Although there were 40 ramus screw sites, the total sample size for the current study is only 37. The remaining three cases were bilateral applications of the same treatment, so they are not independent samples. However, bilateral samples are important in a clinical series because they provide information on patient predisposition to failure.

Although the sample size is small ($n = 37$), this study has provided a reliable initial estimate for the failure rate of ramus screws. None of the devices loosened from bone during the 4 month test interval, and the only failures were due to reversible soft tissue problems. It can be concluded the the ramus screw is a reliable option for recovering horizontal impactions, that have an adequate periodontium.

It is important to remember that one of the lower molar impactions, from a patient treatment planned for a ramus screw, was not recovered because it was periodontally compromised. That was the only

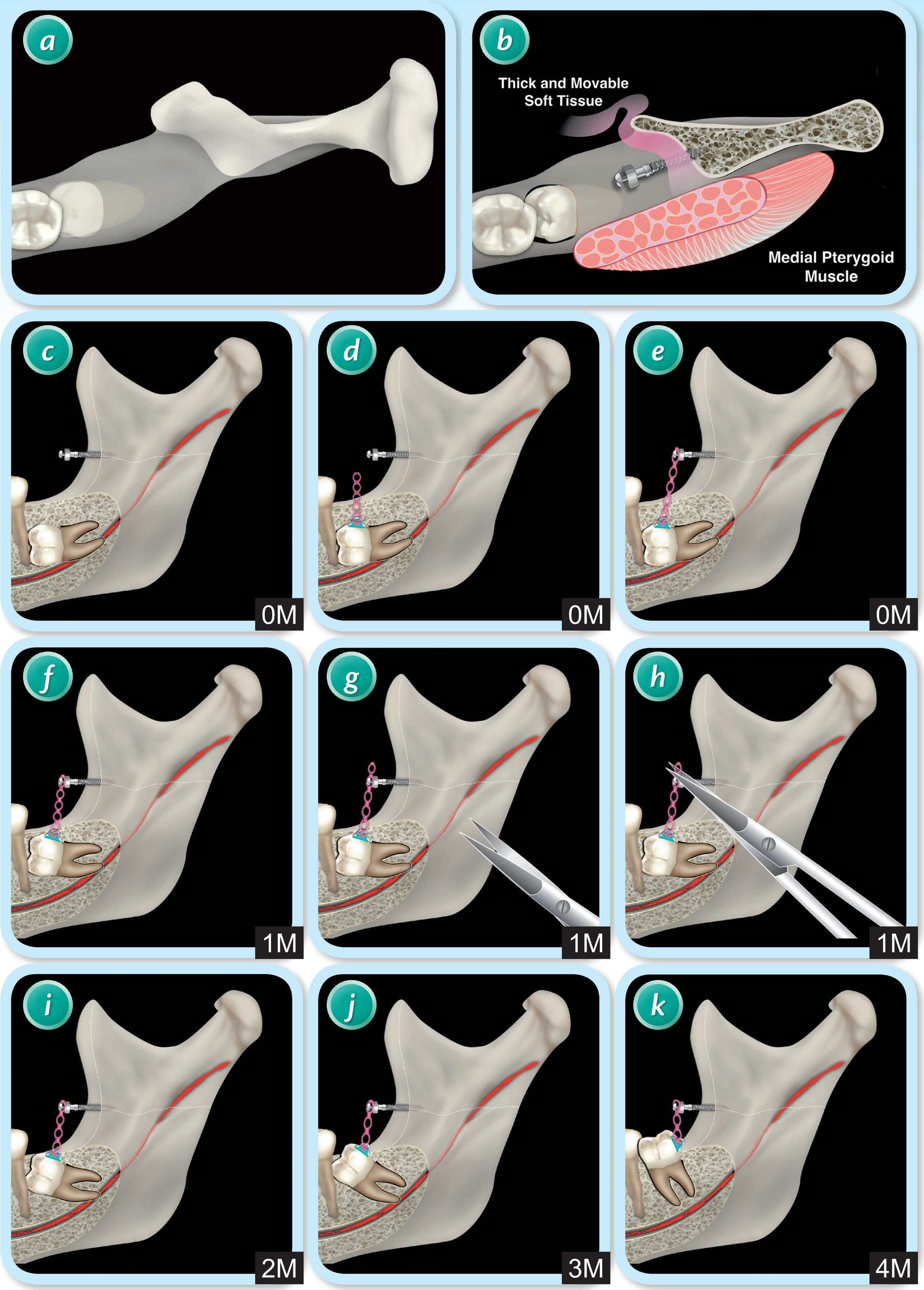


Fig. 10:

A series eleven drawings illustrates the details for ramus screw placement. a. an occlusal semitransparent view illustrates the position for a horizontally impacted molar. b. a similar drawing shows the position of the ramus screw superior to the impaction. c-e. Three progressive drawings reveal the position of the ramus screw, bonding of an attachment with an elastic chain attached to the crown of the impaction, and applying traction to the impaction by attaching the elastic chain to the ramus screw. f-h. similar drawings illustrate reactivation of the elastic chain and trimming it after one month of traction (1M). i-k. The progressive uprighting and extrusion of the impaction is shown after two (2M), three (3M) and four (4M) months of traction. See text for details.

horizontal impaction of a mandibular molar that was excluded. Overall, this study provides a basis for the continuing study of ramus screw efficacy. Future cases will support or refute the conclusions reached with the present inclusive sample of 40 screws in 37 patients (*n = 37*).

Conclusions

1. Deeply impacted, horizontal mandibular molars can be aligned by direct traction from 2x14 mm SS bone screws, inserted in the anterior ramus of the mandible.
2. The method is fast, efficient, and predictable.
3. It is critical to maintain at least 5 mm clearance from the soft tissue to the screw head to facilitate oral hygiene and control soft tissue irritation.
4. The failure rate of the E-A ramus screws (5%) is slightly better than buccal shelf bone screws (*7.2%*),[5] but is much better than I-R miniscrews in the maxilla (*12%*) or in the mandible (*19.5%*).[20,21]
5. The two initial failures out of 40 specimens was due to a reversible soft tissue irritation. Both patients were retreated with the same method to a desirable outcome.
6. In effect, the ramus screw anchorage mechanism was 100% successful for recovering periodontally healthy, horizontally impacted mandibular molars.

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