# The use of temporary anchorage devices for molar intrusion

**Neal D. Kravitz, DMD; Budi Kusnoto, DDS, MS; T. Peter Tsay, DDS, PhD; William F. Hohlt, DDS**

Supraerupted maxillary molars are a common clinical finding in dental practice. Early loss of the mandibular first molar often leads to extrusion of the opposing maxillary first molar into the edentulous space. Re-establishing a functional posterior occlusion requires a comprehensive dental treatment plan involving full-arch braces, headgear, surgical impaction or iatrogenic root canal therapy with significant occlusal equilibration.[1,2] Orthodontic temporary anchorage devices (TADs) provide a minimally invasive treatment alternative, one that does not require the patient's compliance, for molar intrusion.

This article focuses on orthodontic TADs with specific emphasis on their application in molar intrusion.

## ABSTRACT

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**Background.** This article reviews the use of temporary anchorage devices (TADs) for maxillary molar intrusion.
**Types of Studies Reviewed.** The authors reviewed clinical, radiographic and histologic studies and case reports. The studies provided information regarding the application, placement and biological response of orthodontic TADs.
**Results.** TAD-supported molar intrusion is controlled and timely and may be accomplished without the need for full-arch brackets and wires. Supraerupted maxillary first molars can be intruded 3 to 8 millimeters in 7.5 months (approximately 0.5-1.0 mm per month), without loss of tooth vitality, adverse periodontal response or radiographically evident root resorption.
**Clinical Implications.** True molar intrusion can be achieved successfully with orthodontic TADs, re-establishing a functional posterior occlusion and reducing the need for prosthetic crown reduction.
**Key Words.** Temporary anchorage device; intrusion.
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Dr. Kravitz is an orthodontic resident, Department of Orthodontics, College of Dentistry, University of Illinois at Chicago, 801 S. Paulina St., MC 841, Chicago, Ill., e-mail "neal_kravitz@yahoo.com". Address reprint requests to Dr. Kravitz.
Dr. Kusnoto is the clinical chair and an assistant professor, Department of Orthodontics, College of Dentistry, University of Illinois at Chicago.
Dr. Tsay is an associate professor, Department of Orthodontics, College of Dentistry, University of Illinois at Chicago.
Dr. Hohlt is an associate professor, Department of Orthodontics, School of Dentistry, Indiana University, Indianapolis.

## TEMPORARY ANCHORAGE DEVICES

A TAD is a titanium-alloy miniscrew, ranging from 6 to 12 millimeters in length and 1.2 to 2 mm in

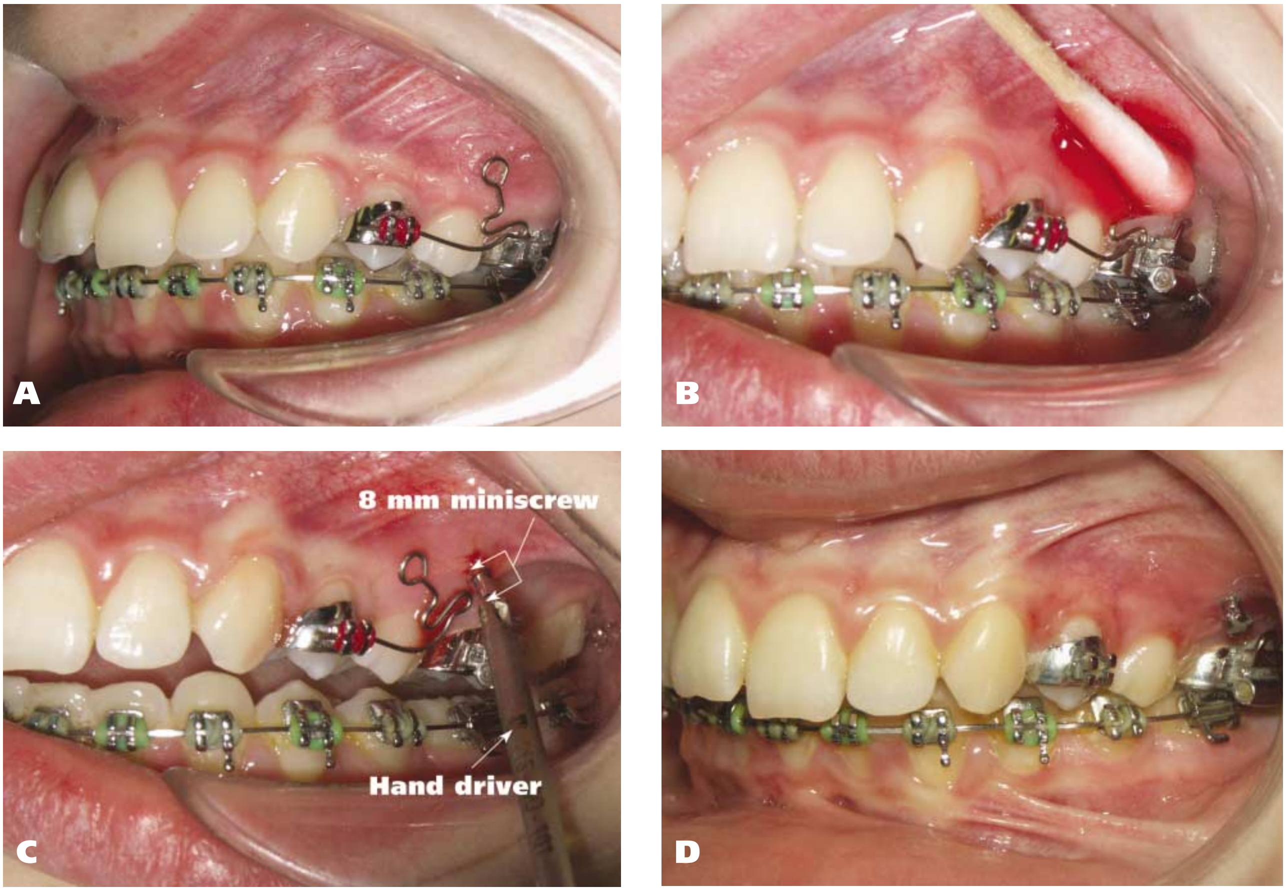


**Figure 1. A.** Surgical guide marks the site of temporary anchorage device (TAD) insertion on a periapical radiograph. **B.** Tetracaine, lidocaine and phenylephinerine 20 percent topical anesthetic applied for five minutes. **C.** Direct insertion of a self-drilling TAD with a hand driver at the mucogingival junction. Angulation 45 degrees from occlusal plane greatly minimizes the risk of root approximation. **D.** Insertion complete and ready for immediate loading (Dual-Top Miniscrews, Rocky Mountain Orthodontics, Denver). Image of DualTop orthodontic miniscrew reproduced with permission of Rocky Mountain Orthodontics.

diameter, that is fixed to bone temporarily to enhance orthodontic anchorage.[3] Placement is minimally invasive and often completed using only topical anesthetic (Figure 1). They can be inserted directly through the gingival tissue into bone with a hand driver. In regions of thick soft tissue and dense cortical bone, a mucosal punch and pilot hole may be placed to help guide insertion. Stationary anchorage is achieved by gripping mechanically to cortical bone, rather than by osseointegration.[4] Therefore, the orthodontist is able to load the TAD immediately, as well as remove it with a simple twist of the hand driver. Stationary anchorage failure of TADs under orthodontic loading varies between 9 and 30 percent.[5-8]

**Self-tapping versus self-drilling TADs.** TADs are either self-tapping or self-drilling in design. Self-tapping TADs feature a conical design with a threaded shaft and a tapered furrow at the tip. These miniscrews often require a pilot hole before being inserted with a hand driver. Self-drilling TADs feature a corkscrew design with a threaded shaft and a sharp tip.[9] The shaft is designed to work like a cutting flute, expelling bone debris onto the surface during insertion.[9] Self-drilling TADs are placed directly with a hand driver without the need for a pilot hole.

**ABBREVIATION KEY. HU:** Houndsfield units. **TADs:** Temporary anchorage devices.

## TREATMENT CONSIDERATIONS

**Patient selection.** TADs are approved by the U.S. Food and Drug Administration for use in patients 12 years and older.[10] Juvenile patients who have not completed skeletal growth, as determined by a hand-wrist radiograph, should not undergo TAD placement directly into the maxillary palatal midline suture.[10] Ossification of the palatal suture will continue through the late 20s.[11] TADs are contraindicated in heavy smokers and patients with bone metabolic disorders.[12]

**Proper location for TAD insertion.** TADs should be inserted into a region with high bone density and thin keratinized tissue. The location chosen should be the optimal one in terms of both the patient's safety and biomechanical tooth movement. Bone density and soft-tissue health are the key determinants that affect stationary anchorage and miniscrew success.[6]

**Bone density and Misch classifications.** Stationary anchorage failure often occurs because the TAD was placed in a region of low bone density with inadequate cortical thickness.[13] Misch[14] classified bone density into four groups—D1, D2, D3 and D4—based on the number of Hounsfield units (HU)—units of measurement used in computed tomographic scanning to characterize tissue density. D1 (> 1,250 HU) is dense cortical bone primarily found in the anterior mandible, buccal shelf and midpalatal region. D1 bone has the tactile analogue of oak. D2 (850-1,250 HU) is porous cortical bone with coarse trabeculae found primarily in the anterior maxilla, the midpalatal region and the posterior mandible. D2 bone has the tactile analogue of pine. D3 (350-850 HU) is thin (1 mm), porous cortical bone with fine trabeculae, found primarily in the posterior maxilla and mandible. D3 has the tactile analogue of balsa wood. D4 (150-350 HU) is fine trabecular bone, found primarily in the tuberosity region (Figure 2). D4 has the tactile analogue of polystyrene foam.[14]

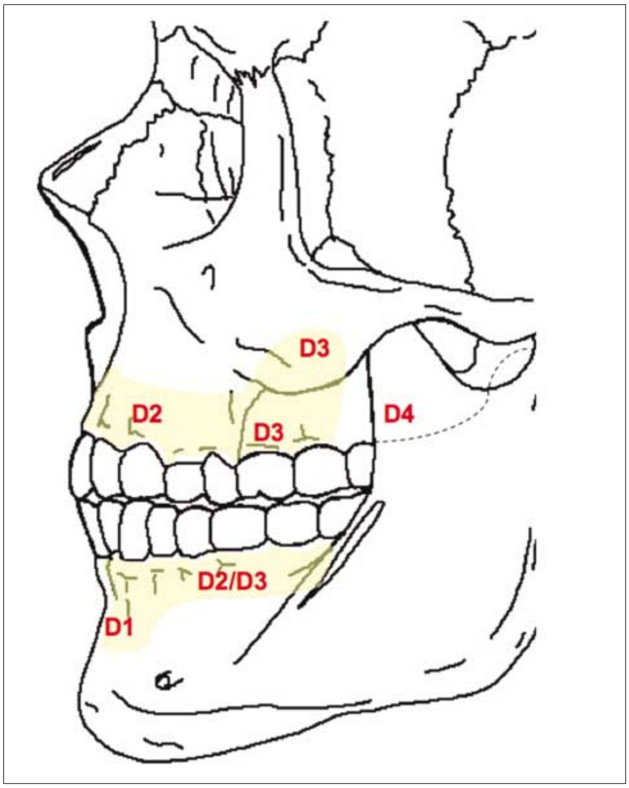


**Figure 2.** Regions of bone density (as classified in Misch.[14]) D1 bone has the highest density. D4 bone has the lowest density and is not recommended for placement. Temporary anchorage devices (TADs) can be placed in D1 to D3 bone (yellow region) with a 70 to 90 percent success rate. The maxillary midpalatal region (not shown) contains D1 and D2 bone. TADs placed in the retromolar pad or zygomatic region may require a flap; patients requiring such placement should be referred to a surgeon.

Regions of D1 to D3 bone are adequate for TAD insertion. TADs placed in D1 bone may require a drilled purchase point to perforate the thick outer cortical plate. TADs placed in D1 and D2 bone exhibit lower stress at the screw-bone interface and may provide greater stationary anchorage during loading.[15] Placement in D4 bone is not recommended owing to the high failure rate associated with it (35-50 percent).[16,17]

**Soft-tissue health.** Inflammation of the surrounding soft tissue is directly associated with stationary anchorage failure.[6,7] TADs placed in nonkeratinized alveolar tissue have a greater failure rate than those inserted into attached tissue.[6] The loose alveolar tissue is irritated easily, leading to gingival inflammation and overgrowth of the miniscrew head. In the buccal posterior region where the mucogingival junction is shorter, the clinician may choose to place the TAD in alveolar mucosa to avoid root proximity.

**Bone availability.** In the maxillary posterior dentoalveolus, the greatest amount of interradicular bone is located between the second premolar and first molar, 5 to 8 mm from the alveolar crest.[18,19] In the mandibular posterior dentoalveolus, the greatest amount of interradicular bone is on either side of the first molar, approximately 11 mm from the alveolar crest. In the anterior region of the maxilla and mandible, the greatest amount of interradicular bone is located between the canine and lateral incisor.[18,19] If inadequate interradicular bone is available, the clinician can place the TAD palatally or diverge the roots before inserting it.

## PLACEMENT OF TEMPORARY ANCHORAGE DEVICES

**Insertion technique.** Proper angle of insertion is important for cortical anchorage, the patient's safety and biomechanical control. In the posterior

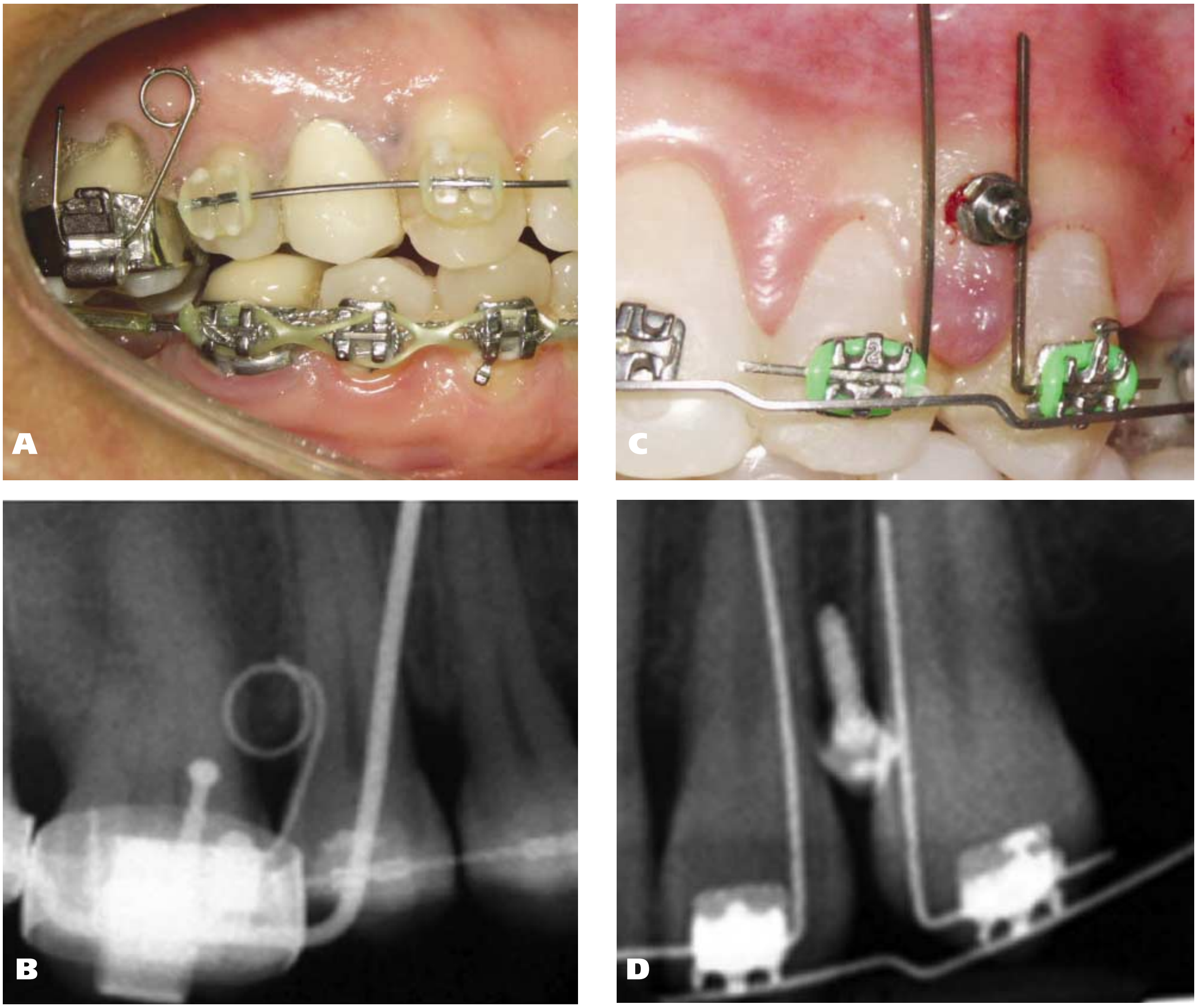

**Figure 3.** Surgical stents. **A.** Before insertion in the posterior region, a 16 round stainless steel wire is placed at the level of the mucogingival junction. **B.** Radiographic confirmation of adequate interradicular bone thickness and proper insertion site. **C.** Before insertion in the anterior region, 16 x 16 stainless steel wires are placed outlining the outer margins of the roots (technique was introduced by W.F.H.). **D.** Postoperative radiograph confirming accurate interradicular placement.

maxilla, the angle of insertion should be 30 to 45 degrees to the occlusal plane.[20] Steeper angulation (< 30 degrees) minimizes the risk of root perforation but may increase the risk of miniscrew slippage. In the anterior maxilla and posterior edentulous maxilla, the angle of insertion should approximate 90 degrees to the occlusal plane (parallel to the paranasal sinus floor) to minimize perforation of the sinus.[21] This allows for a more gingival position of the TAD head, which is biomechanically advantageous during molar intrusion. In the mandible, the angle of insertion should be 30 to 45 degrees to the occlusal plane to increase the surface area contact between the miniscrew and the thicker cortical bone.[20] A surgical stent made of orthodontic wire can be used to guide insertion (Figure 3).

**Force load.** In regard to stationary anchorage, numerous articles have recommended loading forces of 300 grams of force or less.[5,6,22-27] Dalstra and colleagues[28] suggested loading forces of 50 g in regions of thin cortical bone and fine trabecula. Buchter and colleagues[22] reported that TADs inserted into dense mandibular bone remained clinically stable at forces up to 900 g. In regions of poor bone density, simply placing a longer screw or applying lighter force does not ensure stationary anchorage.[6,29]

Intrusive force should be light and continuous to produce the appropriate pressure within the

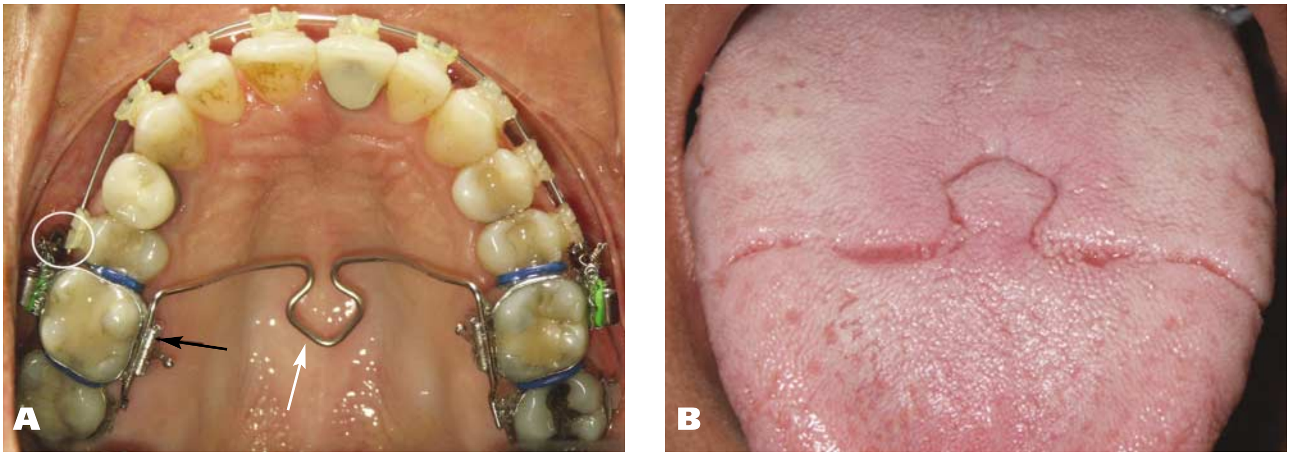


**Figure 4.** Molar intrusion with a single temporary anchorage device (TAD) and a transpalatal bar. **A.** Placement of the TAD between the second premolar and first molar (white circle). Buccal root activation is applied to the transpalatal bar (black arrow). The transpalatal arch is raised 3 to 5 millimeters away from the palate (white arrow). **B.** Resting tongue pressure against the transpalatal bar aids with intrusive forces.

periodontal ligament and minimize the risk of root resorption.[30] Kalra and collagues[31] used 90 g of force to intrude maxillary molars in children; Melsen and Fiorelli[32] used 50 g of force to intrude maxillary molars in adults. Park and colleagues[33] used 200 g of force for miniscrew-supported maxillary molar intrusion, and Umermori and colleagues[34] used 500 g of initial force for miniplate-supported mandibular molar intrusion. The recommended force for miniscrew-supported maxillary molar intrusion is 100 to 200 g. En-masse intrusion of the second premolar and the first and second molar requires greater force, approximately 200 to 400 g per side.[35,36]

**Chlorhexidine rinse.** Chlorhexidine (0.12 percent, 10 milliliters) should be used a minimum of twice daily during the first week after placement and continued throughout the course of treatment if needed to minimize soft-tissue inflammation. Chlorhexidine is a cationic, bacteristatic and bacteriocidal rinse that works via sustantivity within the oral cavity. It has the added benefit of slowing down epithelialization, which may limit soft-tissue overgrowth. After rinsing with chlorhexidine, patients should wait 30 minutes before brushing with fluoridated toothpaste. The anionic agents in fluoridated toothpaste will reduce the activity of the rinse, and the surface contact of the toothbrush will remove the chlorhexidine coating.[37]

## MAXILLARY MOLAR INTRUSION WITH TEMPORARY ANCHORAGE DEVICES

**Protocol.** For maxillary molar intrusion using a single TAD, the miniscrew should be placed in the buccal dentoalveolus between the second premolar and first molar at the mucogingival junction. To prevent the intruding molar crown from tipping buccally, the clinician can place a transpalatal arch with buccal root activation. The transpalatal arch should be raised 3 to 5 mm away from the palate to allow resting tongue pressure to aid with intrusion (Figure 4).

For maxillary molar intrusion using two TADs, one miniscrew should be placed in the buccal region between the first and second molar; the other in the palatal slope between the second premolar and first molar just medial to the greater palatine nerve. This will allow the elastic chain or nickel-titanium coil to pass diagonally across the occlusal table. Owing to the angulation of the palatal slope, there is a tendency for the molar to tip palatally during intrusion. Partial braces may be needed during or after intrusion to prevent the molar from moving into crossbite (Figure 5).

In the absence of adequate interradicular space, TADs can be placed in the palate, either in the midline region or the palatal slope. TADs placed in the midline region often require an extension arm reaching up the palatal slope (Figure 6, page 62). Partial braces from the first premolar to the second molar can be placed to counterbalance palatal crown tipping.

**Rate.** The rate of single molar intrusion[2,32,34-36,38] (Table, page 62) is approximately 0.75 mm per month. Yao and colleagues[2] investigated maxillary molar intrusion in 26 first molars and 17 second molars. The authors reported a mean intrusion of 3 to 4 mm (range, 3.68-8.67 mm) for the first molar and a mean intrusion of 1 to 2 mm for the second molar in 7.5 months. Sherwood and

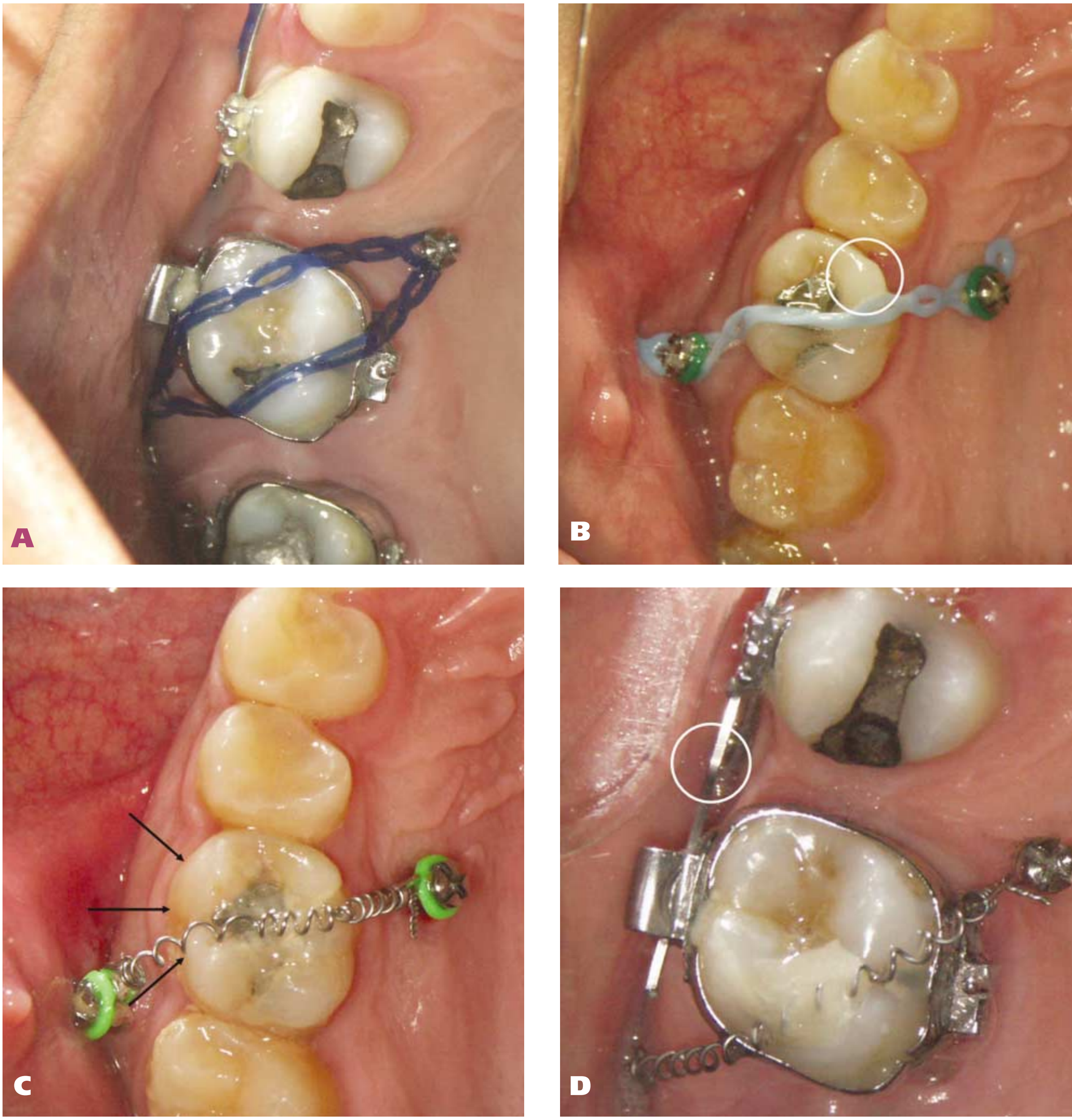


**Figure 5.** Molar intrusion with two temporary anchorage devices (TADs). The buccal TAD was placed between the first and second molar, and the palatal TAD was placed between the second premolar and the first molar. Placement of the palatal TAD mesial to the first molar avoids the greater palatine foramen and D4 bone. **A.** Criss-cross design with elastic chain. **B.** Twisting of the elastic chain and cuspal build-up with resin-based composite (white circle) prevents the chain from slipping off the occlusal table during mastication.**C.** A 150-gram nickel-titanium (NiTi) coil. Notice the tendency of the molar to tip palatally during intrusion (black arrows). **D.** A 150-g NiTi coil stabilized with band cement to the occlusal surface. Partial fixed appliances (white circle) minimize unwanted tipping.

colleagues[38] presented two case reports of maxillary first molar intrusion and reported a mean intrusion of 4.1 mm after 6.5 months. Sherwood and colleagues[39] intruded maxillary first molars in four adults and reported a mean intrusion of 2.0 mm (range, 1.45-3.32 mm) after 5.5 months. Park and colleagues[33] presented two case reports of maxillary first and second molar intrusion and reported an intrusion rate of 0.5 to 1.0 mm per month (Figure 7, page 63).

The rate of en-masse intrusion of the second premolar and the first and second molar is approximately 0.5 mm per month. Erverdi and colleagues[36] performed en-masse intrusion in 10 adults and reported that the maxillary first molar intruded 2.6 mm in 5.1 months. In a case report of en-masse intrusion by Erverdi and colleagues,[35] the authors found that the maxillary first molar intruded 3.6 mm in seven months. In a case report by Yao and colleagues[1] in which the first and second molars were intruded simultaneously, the authors reported that the first molar and second molar intruded approximately 3 mm in five months.

**Root resorption.** Teeth undergoing orthodontic intrusion may be highly susceptible to root resorption.[40] Pressure from intrusive forces concentrate at the root apex, leading to compression and necrosis of the periodontal ligament. Several studies have examined root resorption of posterior teeth in regard to traditional orthodontic treatment. Sharpe and colleagues[41] reported that molars have the second highest incidence of root resorption, after incisors. Beck and Harris[42] reported root resorption in first molars undergoing tip-back and intrusion mechanics. McNab and colleagues[43] reported root resorption of the maxillary first molar after distalization and intrusion with a high-pull headgear. Reitan[44] showed histologically that resorption may occur in premolars subjected to 25 to 240 g of force. In contrast, Owman-Moll[45] reported no difference in root resorption for premolars undergoing light (50 g) and heavy (200 g) orthodontic load in the buccal direction.

## DISCUSSION

Miniscrew-supported molar intrusion has drawn great interest among researchers, especially in terms of whether molars can be intruded under continuous heavy force without significant root resorption or perforation of the sinus floor. Ari-Demirkaya and colleagues[46] measured root resorption of maxillary first molars after intrusion with TADs. The study compared 16 consecutively treated adults who underwent molar intrusion by means of skeletal anchorage with a control group of 16 adults who had undergone fixed orthodontic treatment without molar intrusion. The authors concluded that the amount of root resorption detected after molar intrusion was not clinically different from that in control groups treated without intrusion mechanics. In an animal study, Daimaruya and colleagues[47] intruded maxillary second premolars into the nasal floor of six beagles to histologically elucidate the effects of molar intrusion against the maxillary sinus floor. The beagle's nasal sinus and bony floor are histologi-

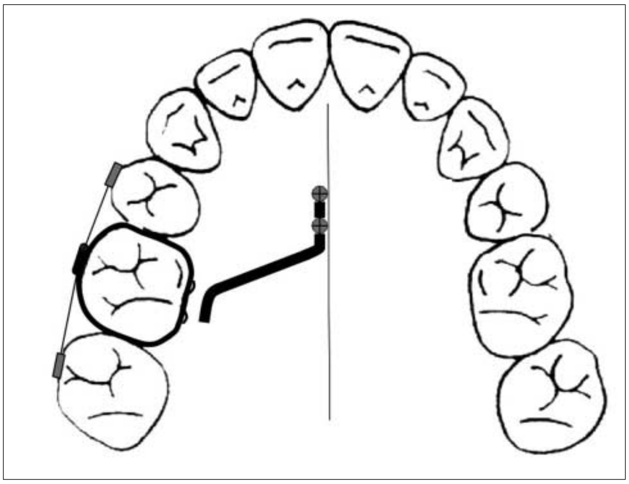

**Figure 6.** Extension bar. Palatal miniscrews will require an extension bar to reach up the palatal slope for molar intrusion. Often, two temporary anchorage devices are placed to prevent rotation of the bar. Partial fixed appliances minimize palatal crown tipping.

**TABLE**

**Amount of maxillary molar intrusion and length of active intrusion time.**

| STUDY | TOOTH MEASURED | INTRUSION TIME (MONTHS) | MEAN AMOUNT OF INTRUSION (mm*) |
|---|---|---|---|
| **Single-Tooth Intrusion** | | | |
| Yao and colleagues[2] | First molar<br>Second molar | 7.5<br>5.0 | 3-4 (range, 3.68-8.67)<br>1.0-2.0 |
| Park and colleagues[33] | Second molar<br>First molar | 5.0<br>8.0 | 0.5-1.0 mm/ month |
| Sherwood and colleagues[38] | First molar<br>Second molar | 5.5<br>7.5 | 4.0<br>4.2 |
| **En-Masse Intrusion** | | | |
| Yao and colleagues[1] | First molar<br>Second molar | 5.0<br>5.0 | 3.0<br>2.0-3.0 |
| Erverdi and colleagues[35] | First molar | 7.0 | 3.6 |
| Erverdi and colleagues[36] | First molar | 5.1 | 2.6 |
| Sherwood and colleagues[39] | First molar | 5.5 | 2.0 (range, 1.45-3.32) |

* mm: Millimeters.

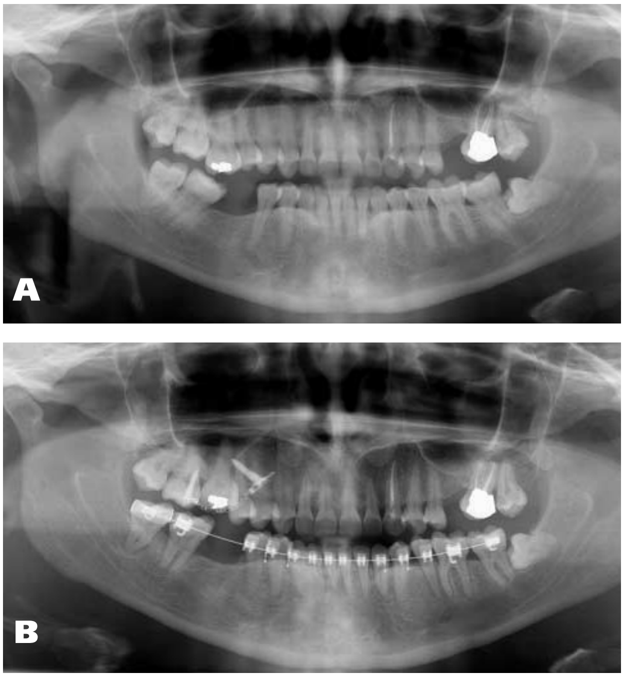

**Figure 7. A.** Pretreatment panoramic radiograph of patient with a supraerupted maxillary first molar as a result of early loss of the mandibular first molar. **B.** Postintrusion panoramic radiograph taken before removal of the temporary anchorage device, showing that 4.4 millimeters of molar intrusion was achieved in less than six months without the need for a fixed appliance. The maxillary molar was intruded within the maxillary sinus without radiographically detectable root resorption. A removable retainer was made to allow the molar to settle into proper occlusion.

cally similar to the human maxillary sinus. The authors reported a mean apical root resorption (± standard deviation) of only 0.18 ± 0.18 mm after seven months of intrusion. The sinus floor membrane lifted intranasally with the intruding palatal root.

**Risks and complications of molar intrusion.** The potential risks of TAD placement must be understood clearly by both the clinician and the patient.

- *Root trauma.* Trauma to the periodontal ligament or dental root may lead to loss of tooth vitality or ankylosis. If there is no pulpal involvement, the outer root and periodontium may demonstrate complete repair in three to four months.[48]
- *Stationary anchorage failure.* TADs may become loose,[6] tip and extrude[29] under orthodontic load. Miniscrews that become mobile will not regain stability and may need to be removed and reinserted. Inadequate primary stability on initial placement likely is a result of inadequate cortical bone thickness.[49] Delayed mobility that occurs days or months after placement likely is a result of inadequate cortical thickness and excessive force load.[50]
- *Soft-tissue irritation.* TADs placed in loose alveolar mucosa may result in soft-tissue irritation, tissue overgrowth and minor aphthous ulceration.[6]
- *Nerve injury.* Placement of TADs in the maxillary palatal slope risks injury to the greater palatine nerve. The greater palatine nerve exits out its foramen, which is located laterally to the second or third molar,[51] and it travels anteriorly along the palatal slope 5 to 15 mm from the gingival border.
- *Sinus perforation.* Small (< 2 mm) perforations of the paranasal sinus floor will heal by themselves without complications[52,53] and should not affect miniscrew stability.[54] Larger perforations may result in sinusitis or a chronic oroantral fistula.[52] TADs diameters rarely exceed 2 mm, and TADs may not need to be removed if the patient is asymptomatic.
- *Relapse.* Relapse extrusion of intruded molars may occur. The average relapse rate for first and second molar intrusion is approximately 30 percent.[54]

## CONCLUSION

The scope of orthodontics is expanding. TADs have allowed the orthodontist to overcome anchorage limitations and perform difficult tooth movements predictably and with minimal patient compliance. Restorative dentists, periodontists and surgeons should ensure that they have a clear understanding of the many applications of orthodontic TADs when presenting patients with options for correcting occlusal problems. ■

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