Guided Infra-Zygomatic Screws: Reliable Maxillary Arch Retraction

Introduction

The infra-zygomatic crest (*IZC*) is a buccal process on the maxilla, connecting to the zygoma. Intraorally it is a crest of bone emanating from the buccal plate of the alveolar process, lateral to the roots of the first and second maxillary molars (*Fig. 1A*). The ridge of bone extends 2cm or more superiorly to the zygomatic-maxillary suture, and the inferior portion can be subdivided into the IZC 6 and IZC 7 areas, respectively (*Fig. 1B*). The IZC is a common site for insertion of temporary anchorage devices (*TADs*). Melsen[1] and Uribe[2] placed routine TADs along the intraoral anatomical ridge of the IZC, and Villegas[3] used a 25mm long screw to engage the superior aspects of the IZC, approximating the zygoma.

The amount of alveolar bone buccal to the maxillary molars is the critical factor for placing OrthoBoneScrew® (*OBS, Newton's A Ltd, Hsinchu, Taiwan*) in an Extra-Radicular (*E-R*) position. Inter-radicular (*I-R*) TADs are also effective for maxillary retraction, if the screws avoid the path of distal tooth movement. This article reviews the relevant anatomy and clinical procedures for routinely achieving maxillary retraction with TADs, inserted directly into alveolar bone of the posterior maxilla. (*Int J Orthod Implantol 2017;46:4-16*)

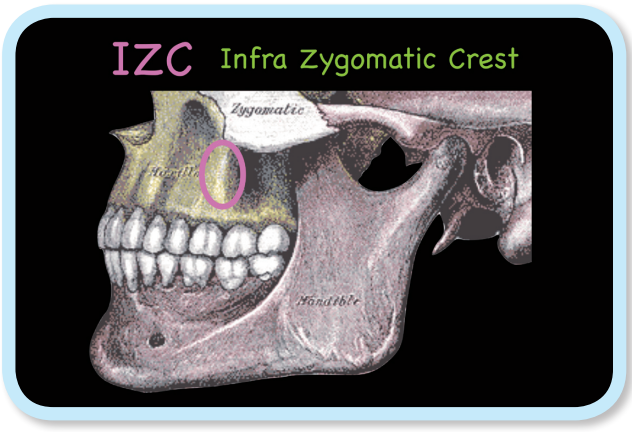

Fig. 1A:
The skeletal anatomy (osteology) of the Infrazygomatic Crest (IZC) is marked with an ovoid magenta circle.

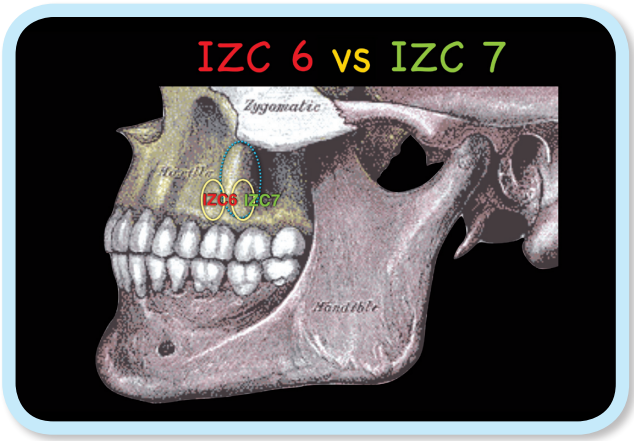

Fig. 1B:
A practical position for an IZC bone screw is anterior to the anatomic ridge and buccal to the mesiobuccal root of the maxillary first molar (MBR of U6). Distal to the anatomic ridge, the preferred site is buccal to the MBR of U7. These TAD sites are designated as IZC 6 and IZC 7 (yellow ovoid circles), respectively.

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Anatomical Considerations

Soft tissue irritation is a common problem if the inferior aspect of the screw platform is contacting or near the mucosa. To control this problem the IZC TADs are placed in attached gingiva with ~1.5mm of clearance from soft tissue to the base of the TAD platform.[4,5] It is important to carefully consider the anatomy of the IZC site to select an appropriate screw length. The average thickness of the attached gingiva in the maxillary first molar is about 1.0mm,[6] and the cortical bone thickness is about 1.1-1.3mm.[7] The screw threads must engage cortical bone to insure primary stability. Generalizing the widths, for soft tissue clearance, attached gingiva and cortical bone at 1.5mm each (*Fig. 2*), reveals that 8-12mm IZC screws penetrate the medullary bone or sinus from 3.5-7.5mm. Under most clinical conditions, an 8mm screw is adequate to engage the cortical plate and secure primary stability (*Fig. 2*).

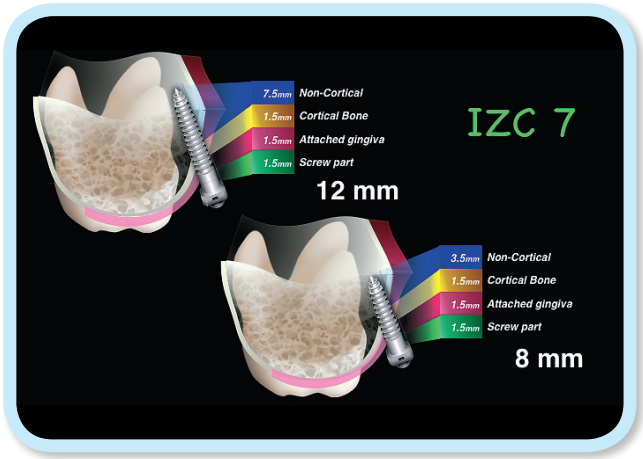
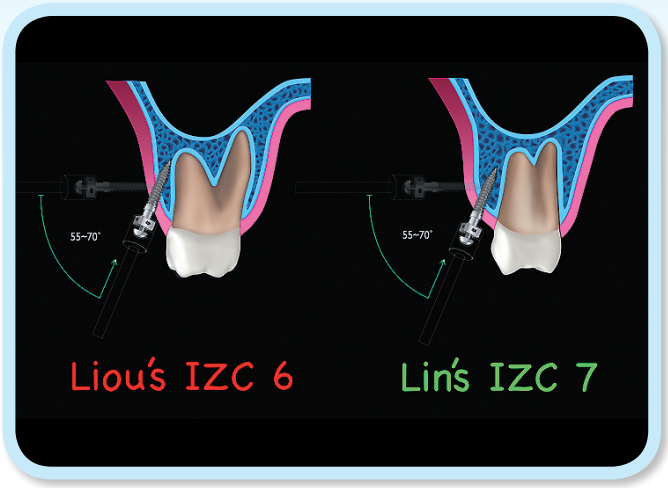


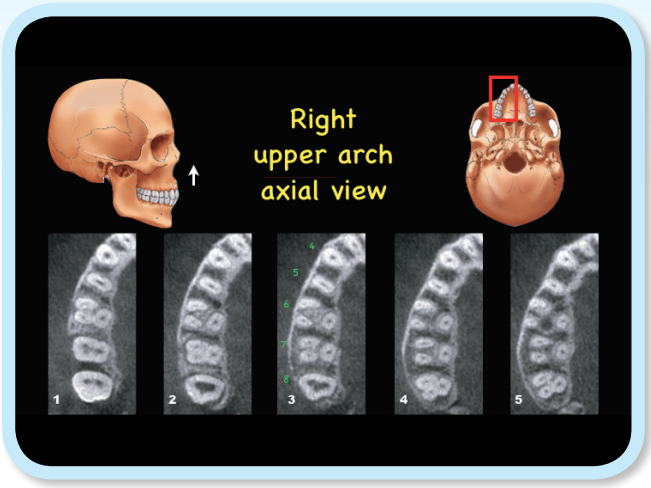
Fig. 2:
An IZC anchorage screw penetrates about a 3mm thickness of attached gingiva and cortical bone. The clearance of the screw head to the soft tissue should be ~1.5mm, so there is a distance about 4.5mm between the base of the screw and the inner surface of the cortical bone. Thus, screws of 8-12mm length will extend into the non-cortical bone space (medullary bone or sinus) about 3.5-7.5mm.

Liou[8] suggested orienting screws about 55-70 degrees inferior to the horizontal plane to achieve maximal buccal bone engagement, but it was not clear whether IZC 6 or 7 was the preferred site from an anatomic perspective (*Figs. 1-3*). Because the alveolar bone is thicker on the buccal surface of the second molar (*Figs. 4 and 5*), the IZC 7 site is usually preferable for TADs.[9] In Taiwan, most orthodontists utilize the IZC 7 site (*Fig. 6A*),[10,11] because the buccal plate covering the first molar roots is too thin. For clinical convenience and the advantage of attached gingiva, the preferred IZC bone screw sites are considerably inferior (*Fig. 6B*) to the anatomic zygomatic crest (*Figs. 1A & B*).

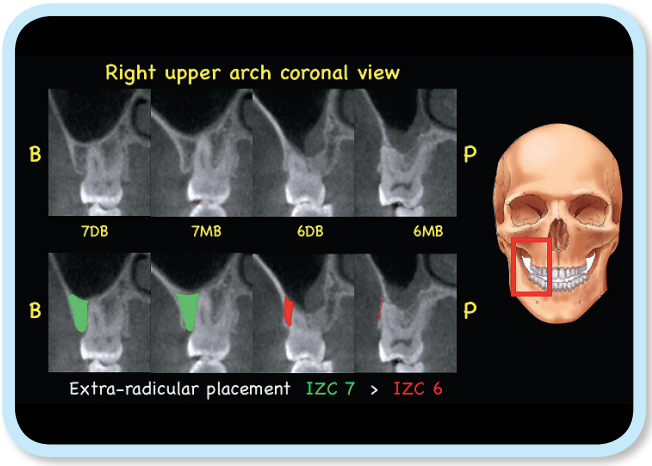
Initially, it was thought that all OBSs (*OrthoBoneScrews, Newton's A Ltd, Hsinchu, Taiwan*) placed buccal to the MBR of U7 were routinely achieving E-R (*Extra-Radicular*) placement for arch retraction. However,



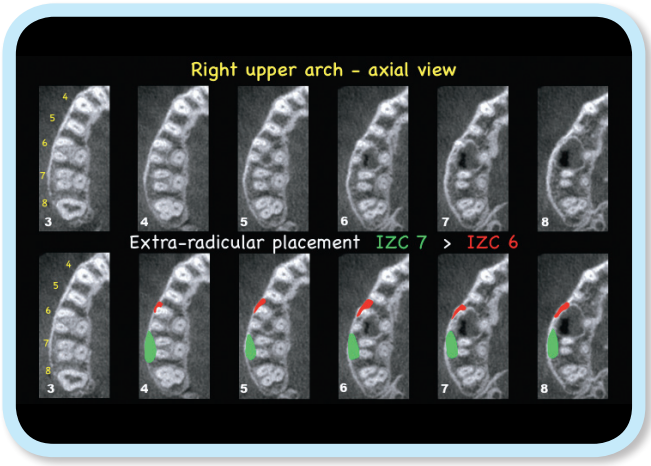
■ *Fig. 3:*
The alveolar bone is too thin to place a TAD buccal to the MBR of 6, even with an increased angulation of 55-70° (Liou's IZC 6). The senior author (JJ-JL) proposes placing an IZC screw lateral to the MBR of 7 (Lin's IZC 7) to more reliably achieve an E-R position for maxillary arch retraction.



■ *Fig. 5A:*
Five CBCT axial cuts (1-5) in the area demarcated by the red rectangle show the alveolar bone anatomy for ~1mm apical to the cementoemamel junction (Cut 1). The teeth are labeled with Palmer notation 4-8. 5-6mm above CEJ is the level where IZC screws are usually inserted. Note that the alveolar bone is much thicker buccal to the U7 compared to the U6.

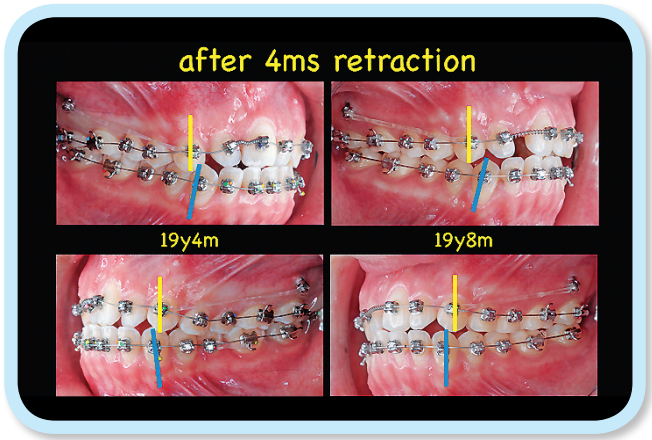


■ *Fig. 4:*
The coronal view of a CBCT (red rectangle) documents alveolar bone thickness on the buccal (B) and palatal (P) aspects of molar roots. Extra-radicular placement of a TAD is more predictable for the IZC 7 compared to the IZC 6 sites, because the bone is thicker over the distobuccal (7DB) and mesiobuccal (7MB) roots of the second molar (U7), compared to the corresponding 6DB, 6MB sites for the first molar (U6).

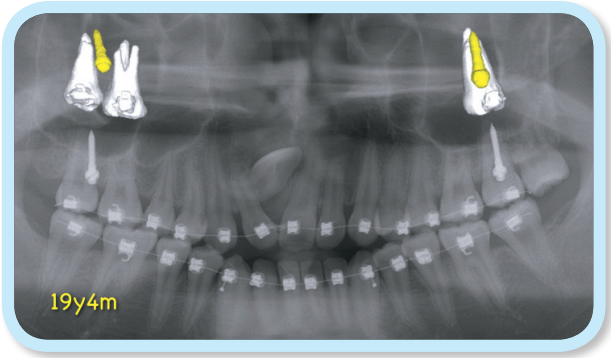


■ *Fig. 5B:*
A similar series of CBCT axial cuts (3-8) from the CEJ apically (series of upper views), is shaded in the series of lower views to show available buccal bone for extra-radicular placement of IZC screws: IZC 7 (green) and IZC 6 (red). See text for details.

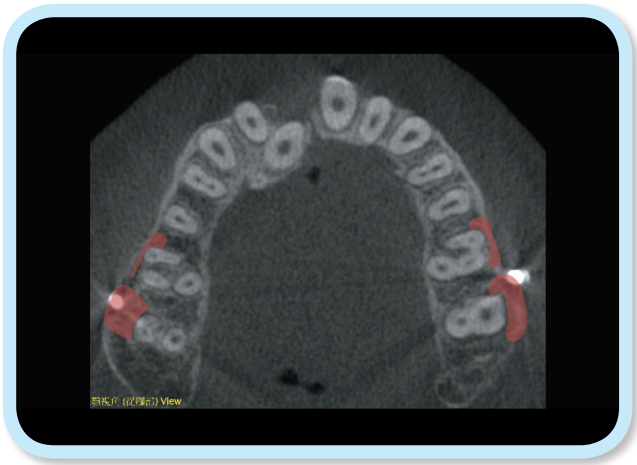
CBCT analysis of consecutive patients revealed some TADs were I-R (*Inter-Radicular*) (*Figs. 6A-D*), and mostly they were E-R (*Fig. 7*). Consistently placing IZC bone screws in an E-R, or carefully selected I-R position, is critical for reliable maxillary arch retraction.



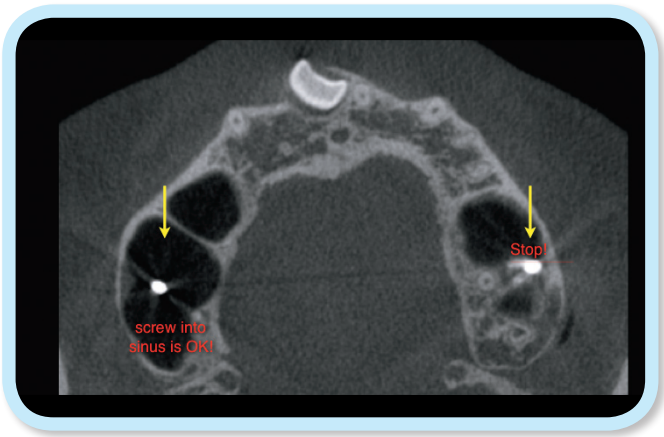
■ *Fig. 6A:*
IZC 7 interference with maxillary retraction is documented for four months (4ms) of treatment from 19y4m to 19y8m of age. Canine cusps are marked with yellow lines in the upper arch and blue lines in the lower arch. Four months (4ms) of retraction with IZC 7 bone screws produced ~2mm of maxillary arch retraction on the patient's right side (upper views), but little or no retraction on the left side (lower views). See text for details.



■ *Fig. 6B:*
3D CBCT images of molars (white) and TADs (yellow) are superimposed on a panoramic radiograph of the patient illustrated in Fig. 6A. The screw on the patient's left side overlaps the root apex and may be interfering with maxillary arch retraction. See text for details



■ *Fig. 6C:*
A horizontal maxillary cut of the CBCT show the IZC 7 screws are inserted in bone, buccal to the roots of the molars (red shading).



■ *Fig. 6D:*
A similar CBCT cut near the apices of the second molars shows the screw on the right side penetrated the sinus, but it is extra-radicular and still provided effective anchorage to retract the right buccal segment, and the patient had no symptoms or complaints. The left IZC 7 impinged on the distal surface of the MBR of the U7, preventing retraction of the left buccal segment in the direction of the yellow arrows.

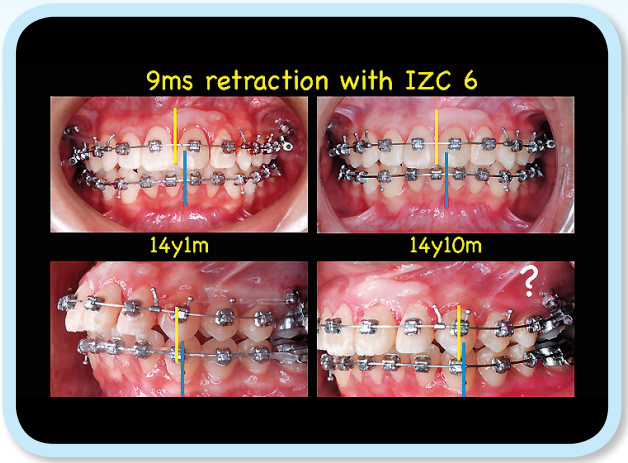


Fig. 7A:
IZC 6 interference with maxillary retraction is documented. A patient 14y1m of age was treated with nine months of maxillary retraction, that was anchored with IZC 6 and IZC 7 screws. Note there is a further deviation of the upper midline to the right, which is consistent with more retraction on the right than the left sides. Little or no progress was noted in correcting the Class II buccal segment on the left side (lower views). See text for details.

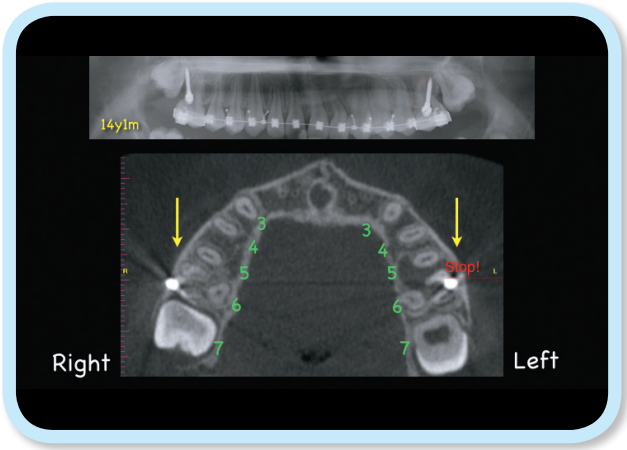


Fig. 7B:
The right IZC 7 is buccal to the roots, and has provided effective anchorage for maxillary retraction (yellow arrows). The MBR of the U6 on the left side interfered with retraction (Stop!). See text for details.

Anchorage Requirements

Originally, the main purpose for TADs in the posterior maxillary arch was for maximal retraction of the anterior segment following extraction of premolars. Ideal I-R placement was right in the middle of the roots of upper 2nd premolar and 1st molar to avoid hitting the roots. In effect, the TADs provided solid anchorage for the extraction space closure. Similar I-R placement of TADs did not work to retract maxillary molars, paradoxically for the same reason: they blocked the path of distalizing tooth movement. Thus, substantial retraction of the entire maxillary arch was not much or not possible with routine I-R TADs.

Clinical experience with OBSs placed in the IZC 6 and 7 areas revealed that maxillary arch retraction was accomplished more often with TADs in the IZC 7, rather than the IZC 6 position. CBCT evaluation demonstrated that the TADs, successfully anchoring maxillary arch retraction, were placed in an E-R position of the relatively thick buccal bone (*Figs. 3-5*).

A truly reliable (*"fail-proof"*) method for maxillary retraction must evaluate bone quality as well as quantity at the TAD site. Chang et al.[12] recently found an IZC screw failure rate of <7%, compared to ~20%, as reported by Uribe.[2] The improved performance of the Chang et al.[12] method may relate to favorable soft tissue on the more inferior sites like IZC 6 & 7 (*Fig. 1B*), compared to the more superior crestal positions of the TADs used by

Uribe[2] and Melsen[1] (*Fig. 1A*). From the evidence reviewed, it is clear that an E-R bone screw is more reliable for maxillary retraction compared to high IZC[1,2] or routine I-R TADs.[1] The current challenge is to develop a clinical approach that consistently achieves TAD anchorage that reliably supports posterior retraction of the molars.

Double Film Method

Dr. Leslie Chen[13] suggested that screws can be placed mesial to the MBR of either U6 or U7 to achieve maxillary arch retraction. This generalization worked well for the thick buccal bone of the IZC 7, but the IZC 6 site was problematic. It was more difficult to achieve E-R anchorage due to thin buccal bone, so the IZC 6 TADs usually produced I-R interference that blocked the path of distal tooth movement. A CBCT scan is valuable for confirming that an IZC TAD is unlikely to interfere with retraction of the maxillary molars, but 3D imaging is not necessary for placing the TAD. The Chen[13] double film method is a 2D radiographic guide for screw placement in patients requiring IZC anchorage (*Fig. 8A*).

Two Screw Insertion Procedure

A radiograph after the initial, preliminary positioning of the TAD serves as baseline for planning its final position, which is confirmed with a follow-up radiograph. Either periapical, preferably with the long cone technique, or panoramic radiographs are suitable for the double film procedure:

Fig. 8A:
Maximal anchorage for routine space closure after premolars extractions is inadequate for correction of a severe malocclusion in a 16y4m old patient. Retraction of the maxillary buccal segments is required.

1. Initial insertion of the TAD with ~1mm of bone engagement (*Fig. 8B*).
2. Check the position with an initial radiograph (*Fig. 8C*).
3. The screw position is adjusted according to the radiographic image.
4. The preferred position for the screw is immediately mesial to the MBR, for either the IZC 6 or IZC 7 sites.
5. Take a second periapical film to confirm that the position is over the mesial of MBR (*Fig. 8C*).
6. Defining the 3D position of the screw relative to the roots of adjacent teeth requires a CBCT (*Fig. 8D*). If necessary, the TAD can be repositioned.

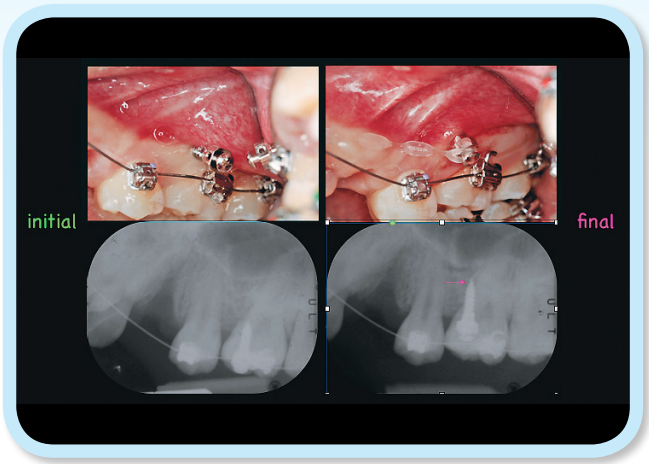


Fig. 8B:
The double film method is effective with periapical radiographs. For the initial film (lower left) the screw is engaged into the bone about 1mm (upper left). The clinical view after the TAD was placed (upper right) and the final film (lower right) shows that the screw (arrow) was reinserted in a more gingival and axial position.

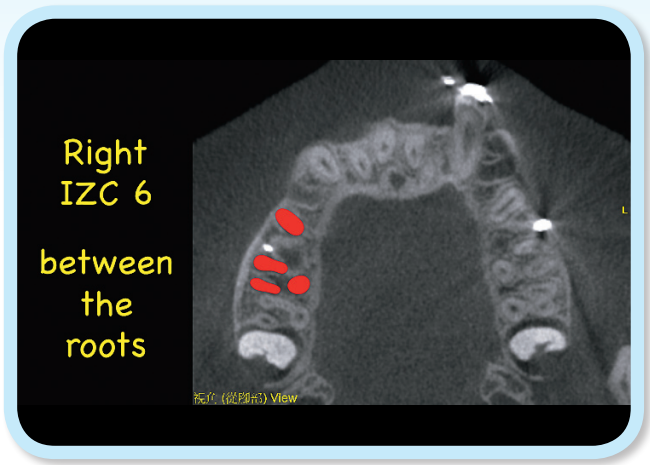


Fig. 8D:
Axial view of a CBCT shows the right IZC 6 is between the roots of the U5 and U6, positioned so the right maxillary segment can be retracted.

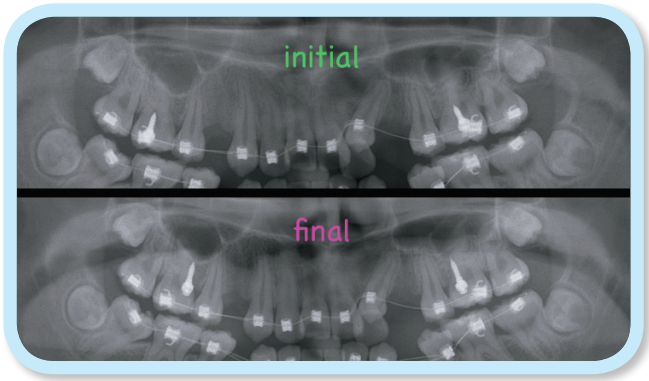


Fig. 8C:
The double film method can also be used with panoramic radiography. On the initial film (upper), space for screw placement is noted between the U5 and U6 roots. The final film shows the screw positioned mesial to the MBR of the U6s. This configuration is suitable for maxillary arch retraction.

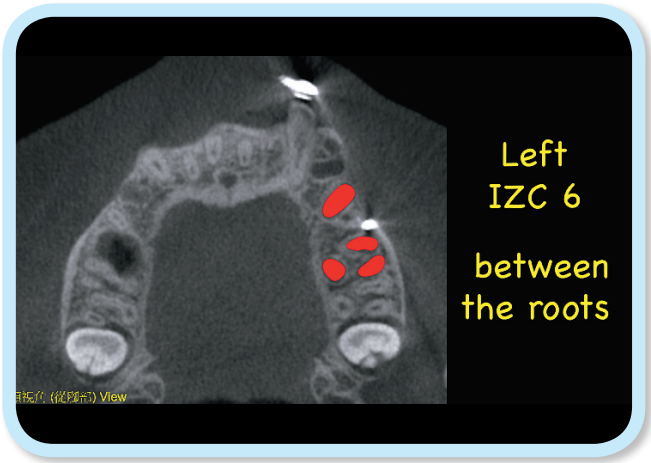


Fig. 8E:
Axial view of a CBCT shows that the left IZC 6 is also in a favorable position between the roots of the first molar and second premolar (shaded in red), so the left maxillary segment can also be retracted.

Advantages:

1. There is usually enough I-R space between the U5 root and the MBR of the U6 for an IZC 6 TAD. Placing the screw in this area is suitable for maxillary arch retraction if it's mesial to the MBR of the U6 and there is adequate clearance for distal movement of the root of the U5.

2. If it is desirable to position the TAD over the mesial of MBR of U7 (*IZC 7*), the chance of extra radicular is much higher.

3. Local infiltration analgesia is recommended to control pain, and fortunately this form of anesthesia does not interfere with the patient's perception of a screw contacting the root. If the patient feels the screw touching the root of a tooth, the TAD can be repositioned.

Disadvantages:

1. Additional wounds occur if screw positioning is changed.

2. Repositioning of the screw is associated with saliva contamination.

Pin Head Soft Tissue Penetration Method

Dr. Mala Ram Manohar[14] presented this innovative method at the 8th World Implant Orthodontics Congress in Goa in 2016. The distinct advantage over the Chen[13] double film method is the lack of saliva contamination associated with reinserting the TAD. The procedure is as follows:

1. Use stainless steel dot pins (*Fig. 9-1*); cut off the heads (*Fig. 9-2*) leaving about a 1mm piece of the shank (*Fig. 9-3*).

2. Canker sore patches (*Fig. 9-4*) used to cover aphthous ulcers (*Fig. 9-5*) are thin, opaque strips or circular patches; and position a pin head in the center of the patch, with the point up (*Fig. 9-6*).

3. Following topical and then local infiltration anesthesia, the circular patch covering the pin-head point is pressed firmly into place, penetrating the soft tissue in the anticipated position of a TAD.

4. Image the area with a 2D radiograph, and reinsert the TAD if needed into a more desirable position; use the soft tissue mark left by the pin head as a landmark.

5. Take a follow-up radiograph to check the final position of the screw, and adjust the TAD position as needed.

Advantages:

1. No saliva contamination of the screw, unless it must be repositioned after the follow-up radiograph.

2. Avoids multiple screw placement wounds.

Fig. 9:

The double film method employs a soft tissue marker that is secured to the soft tissue with an opaque canker sore patch.

1. *Source standard steel dot pins (SS is preferred for sterilization).*
2. *Cut off the pin head.*
3. *Leave about 1mm of the pin shaft to serve as a soft tissue indentation marker.*
4. *Choose a canker sore patch.*
5. *Large patches are inappropriate because they are easily distorted by movable mucosa.*
6. *Select the round canker sore patch and place a pin head in the center of the circle.*
7. *Position the patch with a pin head on the tip of a gloved finger.*
8. *Under local anesthesia, press the pin head into the soft tissue; the patch should maintain the position of the pin head on the soft tissue during the initial radiograph.*
9. *When the patch is removed, the soft tissue indentation of the pin head serves as the mark to reposition the TAD.*
10. *The initial film (x-ray with pin head) has pin head dots marking the soft tissue penetration points.*
11. *The final film shows the "Correct TADs" as placed based on the positions of the initial pin heads.*

Transparent Adhesive Patch for Double Film Technique

1. Source a transparent, adhesive canker sore patch for oral use. It is important that the patch remains firmly attached to soft tissue in the presence of saliva (*Fig. 10A-1,2*).

2. Cut 5mm rectangular patches, remove the protective film, and press the back side of the pin head into the center of the adhesive side of the patch (*Fig. 10A-3*).

3. Under local anesthesia, press the pin head into the soft tissue as before (*Fig. 10A-5*).

4. The transparent patch allows the clinician to see the exact position of the pin head (*Fig. 10A-4,6*).

After an extensive search, ComfortBrace® strips (*Lighthouse Point FL*), originally designed for preventing fixed appliance irritation, were selected as the ideal product because they:

1. Are clear, so the position of the pin head is readily apparent (*Fig. 10A-1*).
2. Can be cut into small 5mm rectangular pieces to be easily positioned on the attached gingiva, and do not move (*Fig. 10A-2,3*).
3. Are made with FDA approved ingredients for use in the oral cavity: polyvinylpyrrolidone, acrylates copolymer, sorbitol, water, hydroxyethyl cellulose, carbomer 980, and mint (*www.comfortbracestrip.com/safety.asp*).

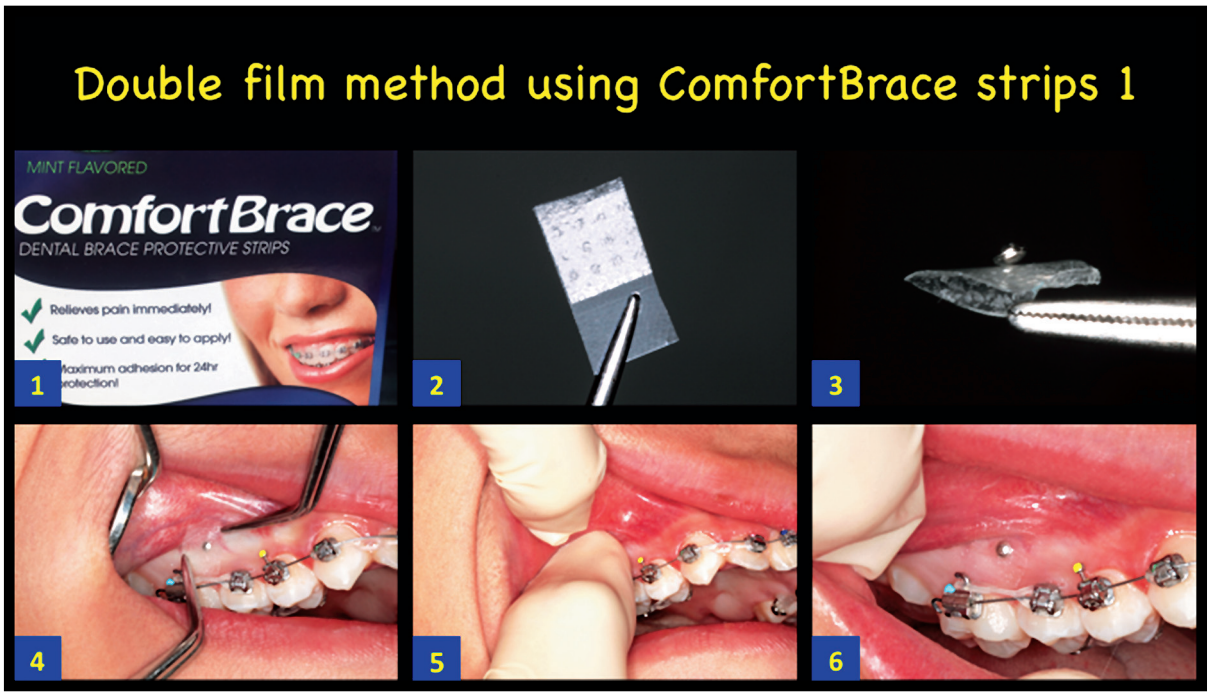


Fig. 10A:
Testing of multiple canker sore patches revealed that ComfortBrace® strips are a better material for the double film method initial film (1).

1. *Protective strips to cover braces have the advantage of soft tissue adhesion up to 24 hours.*
2. *The transparent material is packed in strips with a protective layer that is peeled off prior to application.*
3. *Place the pin head on the adhesive side, with the pin shaft pointed out.*
4. *The very sticky material is best positioned with two sets of forceps.*
5. *After anesthetizing the soft tissue, press the pin head attached to the strip firmly into the mucosa to produce a mark to serve as reference for planning the penetration point for the screw.*
6. *The pin head is held securely by the adhesive strip in preparation for the initial radiograph.*

Indication for IZC 6

1. At least a 5mm gap is required between the roots of the U5 and the MBR of U6 to avoid root contact with an I-R TAD.

2. Small oral cavities are often more convenient to place IZC 6 rather than placing the IZC 7.

3. A buccal frenum on or near the site can induce laceration, inflammation and screw failure; fortunately, there is usually no buccal frenum at the IZC 6 site.

4. The 5mm width of attached gingiva is adequate for most IZC 6 TADs.

5. Avoid placing TADs between the roots of teeth where the sinus floor is low because these areas usually have low density bone and a thin cortical plate.

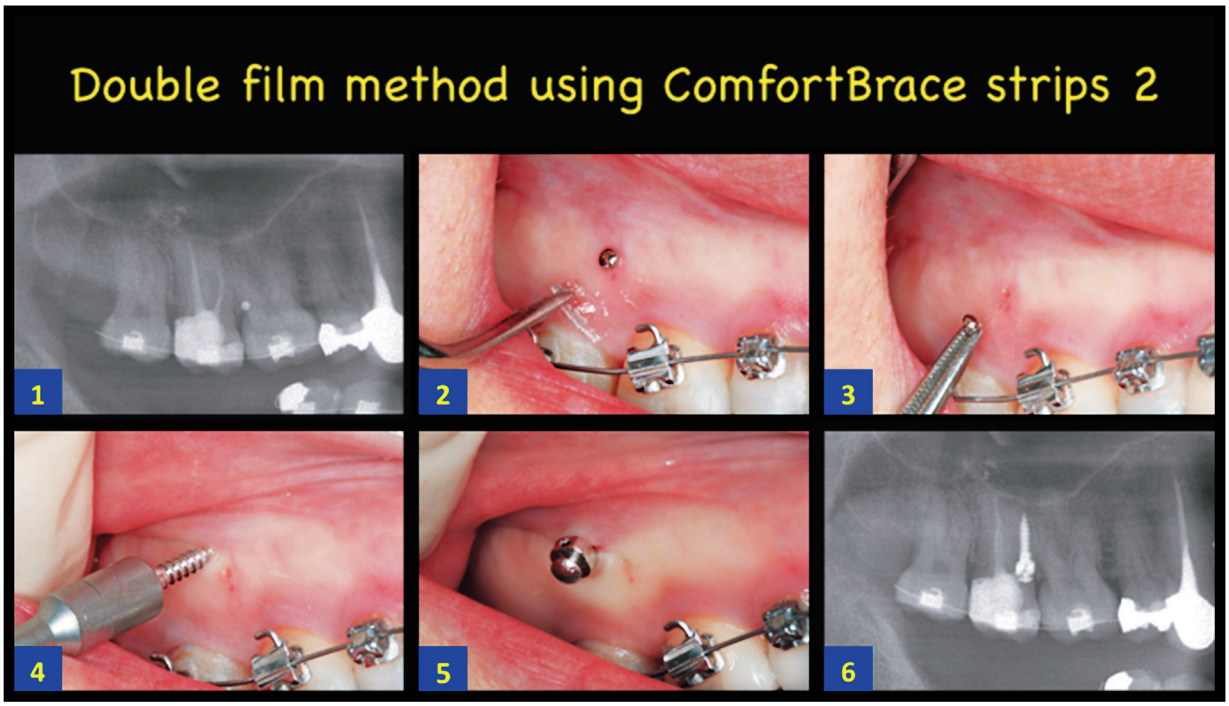


Fig. 10B:
Double film method using ComfortBrace® strips in preparation for TAD placement (2).
1. Initial film shows the dot image of the radio-opaque pin-head.
2. Peel off the clear strip of ComfortBrace® covering the pin head.
3. Remove the pin head, and the soft tissue indentation mark is apparent.
4. Based on the pin head reference, derived from the first film, the TAD is positioned more superior and posterior.
5. The self-drilling screw is installed in the final position.
6. Final film shows the screw positioned mesial to the MBR, as intended.

Indication of IZC 7

1. At least 5mm width of attached gingiva is advantageous.

2. Access to the IZC 7 area requires a large oral cavity, as well as lip reflection for adequate access to the screw insertion site.

3. Avoid placing between the roots of teeth where the sinus floor is low because this area has a thin cortical plate.

Failure rate

According to a recent study by Chang et al.[12] the IZC screw failure rate is <7%. Most of the failures are due to:

1. **Poor bone quality**: Unfortunately there is no reliable method for evaluating bone quality. The sensation for poor bone quality, beneath a sound layer of cortical bone, is like punching through an egg shell, followed by a lack of screw stability. Unless the TAD can be stabilized by deeper penetration, it is best to remove it and try another site.

2. **Immediate loading**: SS screws are excellent TADs because they do not osseointegrate and are easily repositioned to another site, if necessary.

3. **Sinus floor**: A low sinus between the roots of teeth is undesirable for an IZC TAD site.

4. **Movable mucosa**: Unattached alveolar mucosa at the TAD site is usually undesirable.[4,5] However, Chang et al.[12] found no significant difference in the failure rate between movable mucosa and attached gingiva if the platform of the screw is at least 5mm away from the soft tissue surface. The disadvantages of the latter approach are a longer screw is required (*~12mm*) and it must be carefully positioned for patient comfort.

Buccal Shelf Bone Screws

The senior author (*JJ-JL*) previously introduced mandibular buccal shelf bone screws, which were usually placed by periodontists or oral surgeons, using the apically positioned flap to provide attached gingiva at the TAD site.[15] When the mandibular buccal shelf is steep and if patients require an extra-radicular placement, with an apically repositioned flap of attached gingiva, an experienced surgeon is needed. Flap surgery is more expensive and tends to be painful postoperatively, particularly if a TAD must be repositioned. Currently, a skillful orthodontist can produce a good result with a self drilling screw by using the double film method to place the I-R buccal shelf screw (*right mesial to the MBR of L7*). Reliable retraction of the mandibular arch can be done.

Conclusions

1. The double film method is advantageous for installing TADs in the three most common sites: IZC 6, IZC 7, and mandibular buccal shelf.

2. ComfortBrace® strips have proven superior for maintaining a pin head in a stable position relative to the soft tissue.

3. The double film method is indicated for selecting the appropriate point of entry for IZC or buccal shelf screws.

4. Extensive experience with the double film method has demonstrated it is an advantageous approach for reliably placing IZC 6 & IZC 7 bone screws to retract the dentition.

5. The double film method has significant advantages for both the clinician and the patient.

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