

CBCT Imaging to Diagnose and Correct the Failure of Maxillary Arch Retraction with IZC Screw Anchorage

Glossary of Terms

CBCT	Cone Beam Computed Tomography
U6	Upper 1 st molar
U7	Upper 2 nd molar
MB	Mesiobuccal
DB	Distobuccal
IZC	Infra-zygomatic crest
IZC 6	Screw placement buccal U6 (Fig. 1)
IZC 7	Screw placement buccal U7 (Fig. 2)

ABSTRACT

All IZC mini-screws described in this report are made of stainless steel (SS) and are 2mm in diameter. The original preference was for 2mm x 12mm SS screws for both IZC 6 & IZC 7 applications. CBCT imaging has shown that the tip of the 12mm screws may contact the molar roots prevent retraction of the entire maxillary arch. An 8mm screw in the IZC is usually adequate for osseous anchorage, and the shorter screw is less likely to impinge on molar roots. Evaluating bone screw contact with molar roots via CBCT presents special problems for interpreting images. Scattering, distortion and beam hardening prevent clear, realistic images in 3D. Creating a 3D reconstruction of the molar(s) and screw, from a CBCT (0.25mm voxel) using the ITK-SNAP® (<http://www.itksnap.org/pmwiki/pmwiki.php>) software, produces images that are much easier to interpret.¹ The IZC 7 site is a more suitable and safe location for screw placement because the buccal bone plate is thicker, compared to the IZC 6 site. When using IZC screws for anchorage to retract the maxillary arch, regular monitoring of progress is essential. If maxillary arch retraction is slow or arrested, CBCT imaging is indicated. If there is root interference, remove the IZC screw and replace it with a shorter screw in another location, as indicated. (Int J Ortho Implantol 2014;35:4-17)

Introduction

Temporary Anchorage Devices (TADs) were introduced in Taiwan from 2001-2002 via invited presentations: 1. Dr. Park Hyao-Sung (South Korea) Microimplant Anchorage (MIA) system; 2. Dr. Junji Sugawara (Japan) Skeletal Anchorage System (SAS); and 3. Dr. Ryuzo Kanomi (Japan) K1 Mini-Implant System. TADs enjoyed a rapid acceptance in Taiwan, but there were concerns about the limitations of all three methods.

Subsequently, Dr. Eric Liou² (Taiwan) developed a method for infrazygomatic crest (IZC) screw placement adjacent to buccal surfaces of the maxillary first molars.^{2,3} This method is deemed the IZC 6 procedure (Fig. 1). This extra-alveolar (E-A) approach is widely utilized, because there are no interradicular miniscrews to prevent enough full arch retraction, but it is not always successful in retracting maxillary buccal segments. In this report,

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Lin^{4,5} uses CBCT imaging to propose a more distal site that is buccal to the maxillary second molars (IZC 7)(Fig. 2).

There is considerable interest in developing a more predictable IZC temporary anchorage device (TAD), because E-A miniscrews have many important advantages compared to inter-radicular miniscrews: 1. less risk of tooth root damage, 2. more abundant bone allows for a larger screw diameter (2mm), 3. commonly made of stainless steel (SS) which is much

stronger than titanium alloy, 4. 2mm SS screws can be configured with a sharp, cutting tip that is resistant to fracture, 5. less risk of fracture when placed in dense cortical bone, 6. do not interfere with tooth movement, and 7. adequate anchorage for retracting the entire arch to relief crowding and reduce protrusion.

Despite many clinical advantages, the fact remains that IZC miniscrews are not always successful for retraction of maxillary buccal segments. Three case

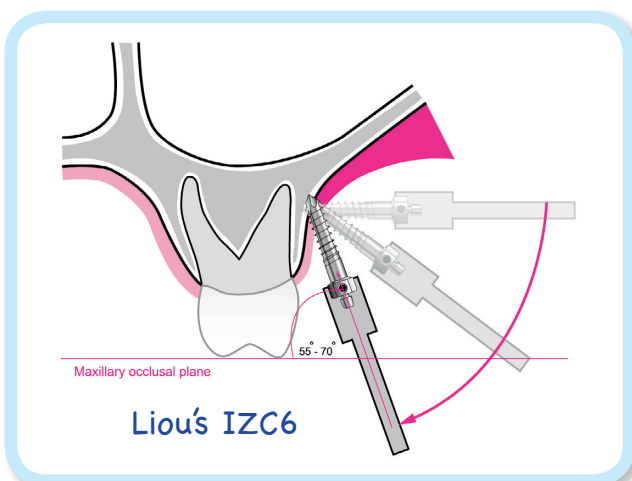


Fig. 1:

The Liou^{2,3} method is illustrated for placing IZC screws lateral to the U6 MB root. The screw is inserted perpendicular to the buccal plate, but once the cortex is penetrated the screw is progressively angled from 55-70° to the occlusal plane as the TAD is screwed into its final position. (Courtesy of Dr. Rungsi Thavarungkul)

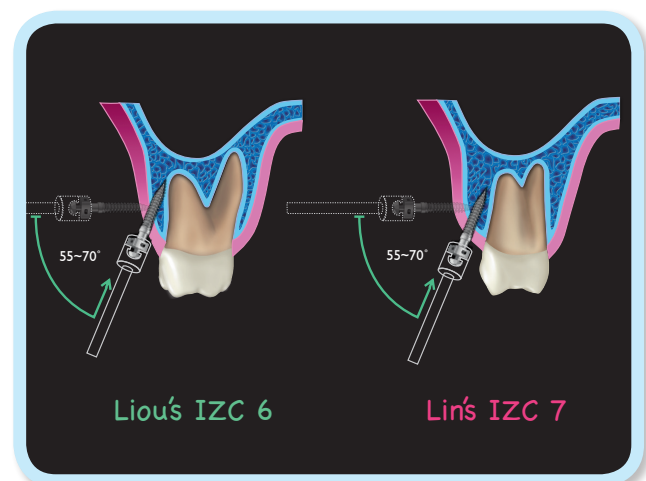


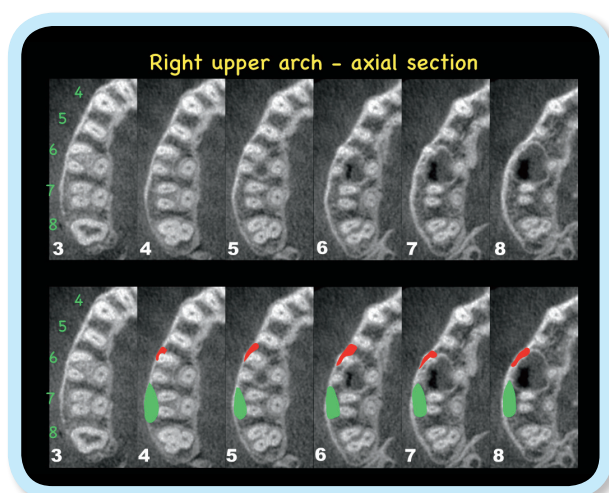
Fig. 2:

The Lin^{4,5} method (IZC 7) is similar to the Liou^{2,3} approach (IZC 6) except the screw is placed buccal to the second molar because there is a thicker buccal plate bone and less divergence of the molar roots. (Courtesy of Dr. Rungsi Thavarungkul)

reports are presented to document IZC anchorage problems. The current report has three clinical objectives: 1. utilize CBCT to define the position of IZC screws relative to the upper molars, 2. determine screw positions that are detrimental for full arch retraction, and 3. develop new techniques to improve the success rate for retracting buccal segments.

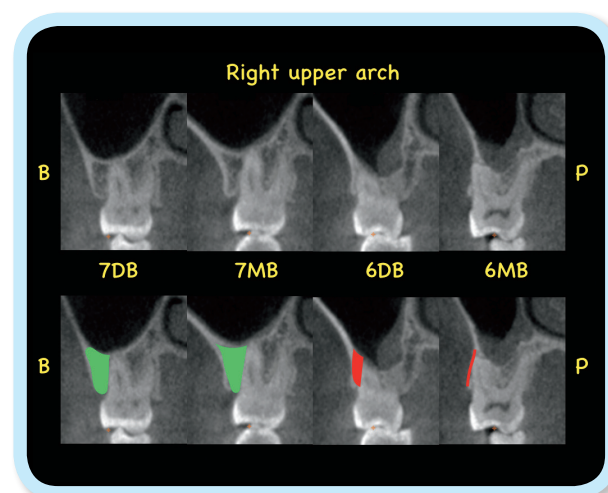
IZC Anatomy

Figs. 3 and 4 are CBCT images of two patients evaluated for IZC TADs. The upper portion of Figs. 3a and 4a are a series of 1mm horizontal cuts through the roots of the maxillary dentition on the right side. The lower portion of both illustrations marks the available bone for the IZC 6 site (*red*) compared to the IZC 7 site (*green*). Figs. 3b and 4b are corresponding coronal views of the first and second molars cut through both the mesial and distal cusps. Again the IZC 6 sites are marked in red and the IZC 7 sites are shaded in green. For both patients, it is apparent that there is considerably more available bone at the IZC 7 site. Not only is the alveolar process thicker, there is less divergence of the second molar roots, compared to the first molar. Thus, it is less likely that a IZC 7 screw placement will contact and interfere with the molar roots.^{4,5} This is a major advantage for the IZC site because interradicular miniscrews commonly contact and injure the roots of teeth.⁶



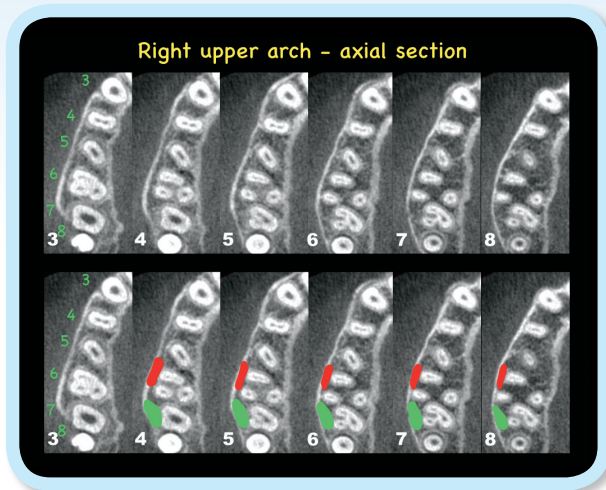
■ Fig. 3a:

The upper half of this illustration is a CBCT axial view of the right side of the maxillary shown in 1mm cuts (3-8) through the midroot area of the molars. The lower half of the figure is a duplicate of the upper illustration, with the available bone for the IZC 6 and 7 sites shaded in red and green, respectively. Note that the buccal bone is much thicker on the lateral surface of the second molars compared to the first.



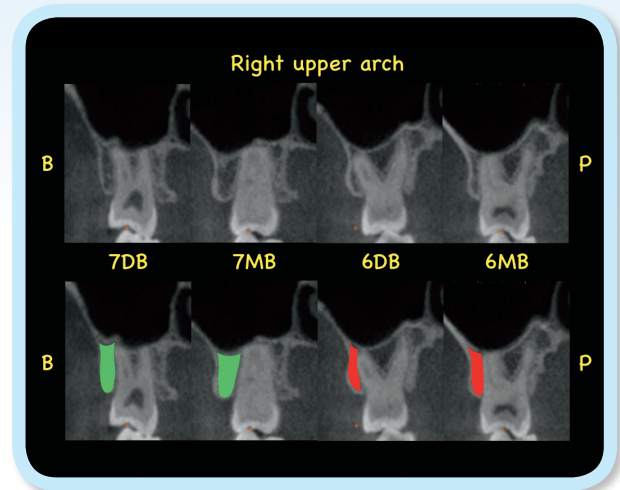
■ Fig. 3b:

The upper half of the illustration is a CBCT in the coronal view of the right upper maxilla, cut through the first (6) and second (7) molar distobuccal (DB) and mesiobuccal (MB) cusps. The buccal (B) and palatal (P) surfaces are marked for orientation. The lower four cuts are a duplicate of the upper images that are shaded in red and green to document the buccal plate of bone for the first and second molars, respectively. Note that the buccal bone is much thicker on the lateral surface of the second molars compared to the first.



■ Fig. 4a:

Similar illustration to Fig. 3a but for a different patient. Again, the buccal plate of bone is much thicker on the lateral surface of the second molars compared to the first.



■ Fig. 4b:

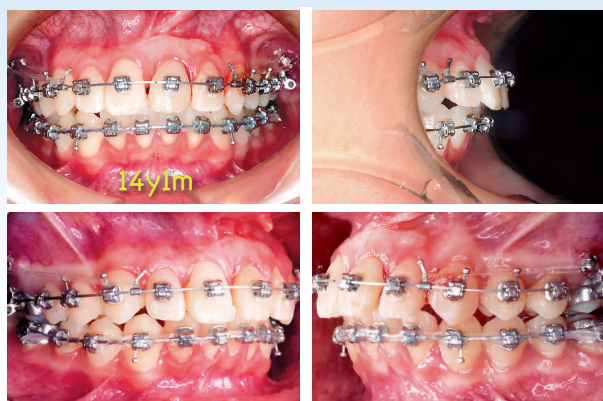
Similar illustration to Fig. 3b but for a different patient. Again, the buccal plate of bone is much thicker on the lateral surface of the second molars compared to the first.

Cases Reports

Case 1 (Figs 5a-i)

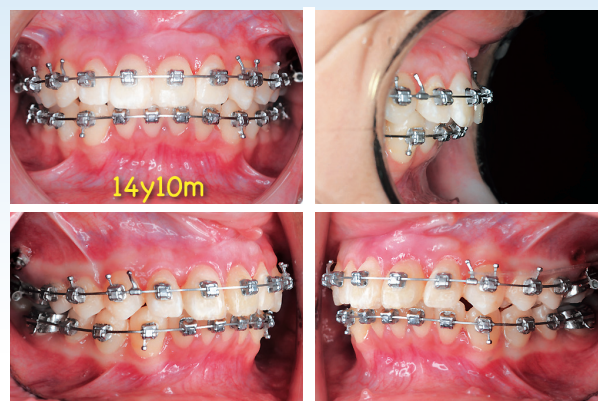
An asymmetric Class II malocclusion (*more pronounced on the left side*) had a large overjet and a midline discrepancy $>3\text{mm}$. IZC 6 screws (2x12mm SS) were placed bilaterally for differential retraction of the buccal segments to correct the molar relationships and midline discrepancy. Intra-oral photographs indicated that the right screw was positioned on the buccal surface of the right upper first molar distobuccal root (RU6 DB), and the left screw was distal to the left first molar mesiobuccal root (LU6 MB). The corresponding panoramic radiograph suggested that both screws were more distally positioned than they appeared in the intraoral photographs.

After 9 months of maxillary arch retraction with elastomeric chains, it appeared that the upper left dentition failed to retract because the molar relationship was still Class II, and there was no improvement in the midline discrepancy. CBCT imaging (Fig. 5f) showed that IZC screw on the left side was contacting the mesiobuccal root (MB) of the first molar, blocking its further movement to the distal (*retraction*). The roots of the right first molar were not in contact with the IZC screw, indicating that further retraction was possible. The left IZC 6 screw was removed, and a new IZC 7 screw (2x8mm SS) was placed, to continue the retraction of the left buccal segment. In 8 months the buccal occlusion on the left side was corrected to Class I and the midline was overcorrected $\sim 1\text{mm}$ (Fig. 5).



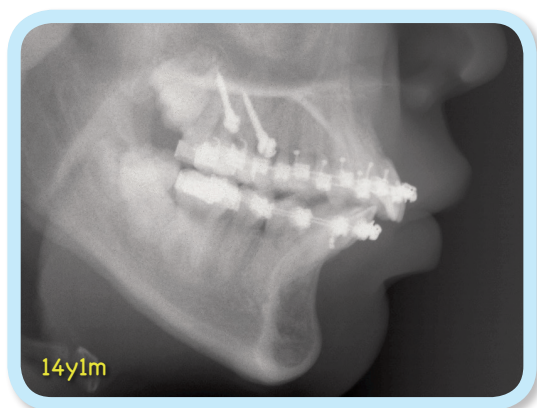
■ Fig. 5a:

Case 1. Asymmetric Class II malocclusion with large overjet and a midline deviation.



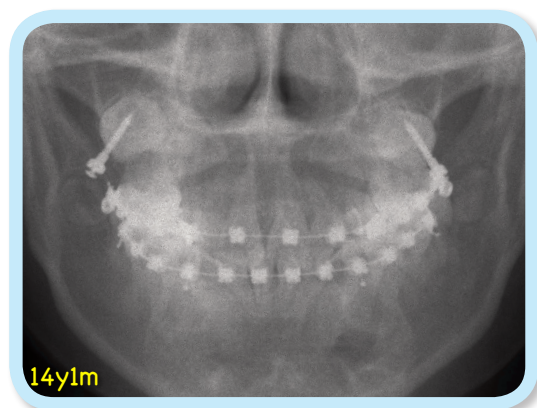
■ Fig. 5b:

Case 1. After 9 months of upper arch retraction, the right side has corrected to Class I, but the left side has not moved relative to the mandibular arch, and it is still Class II.



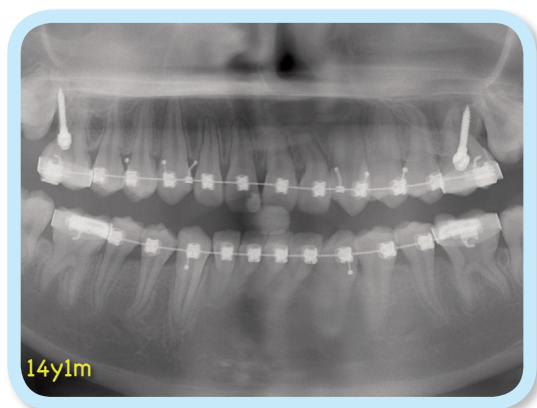
■ Fig. 5c:

Case 1. At the start of treatment, a lateral cephalometric radiograph shows a large overjet, protruded upper incisors and competent lips.



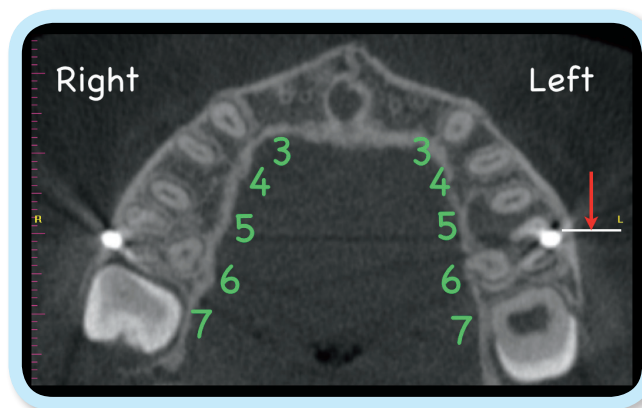
■ Fig. 5d:

Case 1. A frontal cephalometric view shows the orientation of the IZC 6 screws placed lateral to the upper first molar.



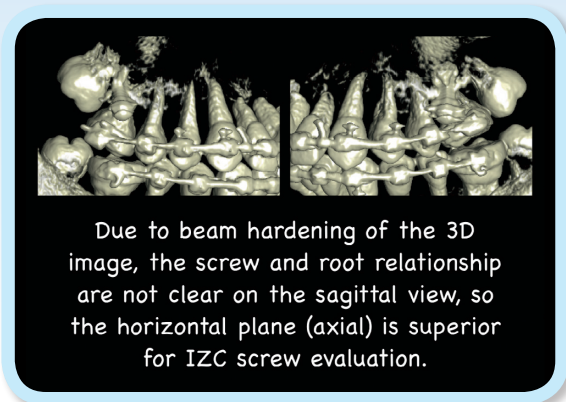
■ Fig. 5e:

Case 1. A panoramic radiograph indicates that the right IZC 6 screw is tilted toward the U6 DB root, and the left IZC 6 screw is tipped distally toward U6 MB root.



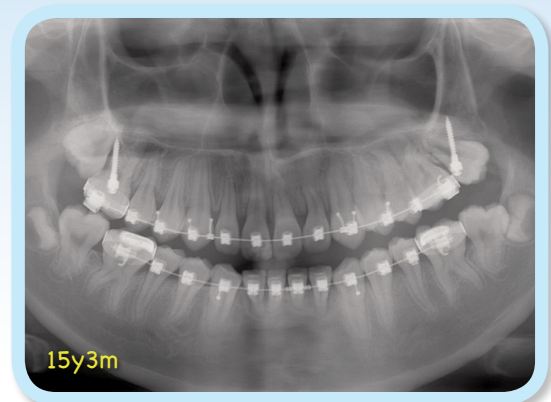
■ Fig. 5f:

Case 1. The axial CBCT view of the left IZC 6 shows that the tip of the screw is engaging the MB root preventing further retraction of the maxillary dentition on the left side.



■ **Fig. 5g:**

Case 1. The 3D image is consistent with Fig. 5f but the view is not as clear due to beam hardening.



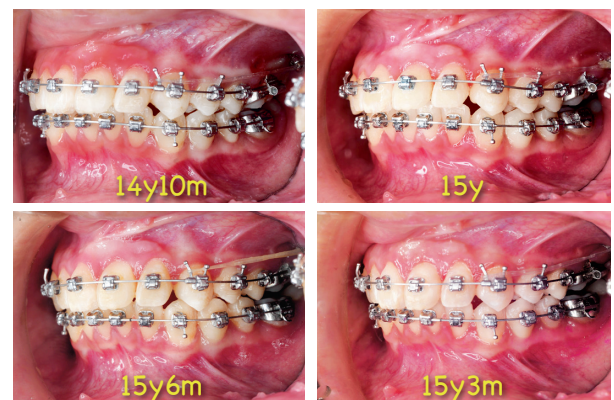
■ **Fig. 5h:**

Case 1. A postoperative panoramic radiograph shows the position of the new left IZC 7 screw.



■ **Fig. 5i:**

Case 1. After 8 months of additional maxillary retraction using the left IZC 7 as anchorage, the upper midline was overcorrected ~1mm.



■ **Fig. 5j:**

Case 1. With 8 months of additional maxillary retraction using the new IZC 7 screw as anchorage, the left buccal segment was corrected to Class I.

What has been learned from this case?

Because of minimal bone at the TAD placement site, an IZC 6 may be placed distal to one of the first molar buccal roots, thereby preventing retraction of the entire buccal segment. When retraction with an active fixed appliance is not achieved in 4-6 months, CBCT imaging is indicated. The objective is to determine if root contact with the screw, has prevented retraction ("distalization"). If root interference with the 12mm IZC 6 screw is detected, remove and place an 8mm IZC 7 screw to continue the retraction of the entire arch.

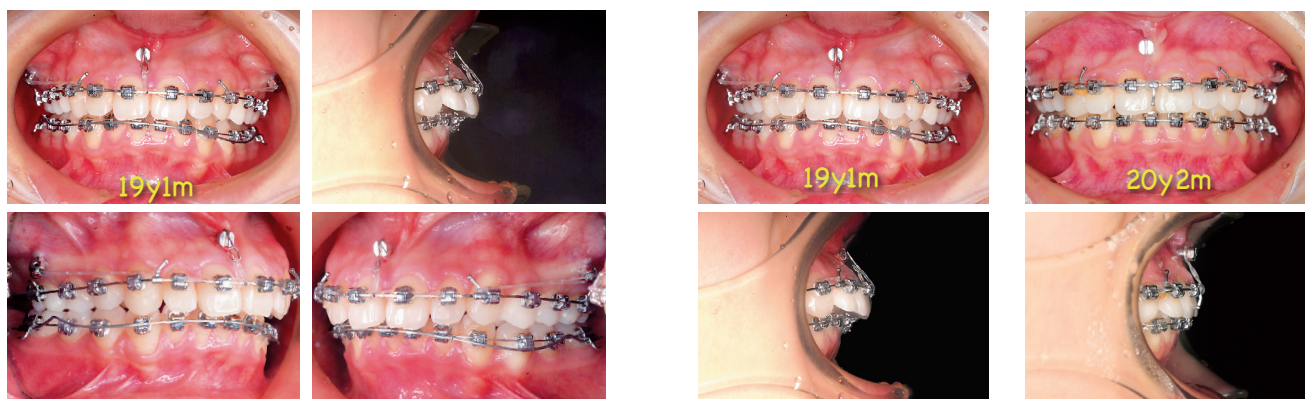
Case 2 (Figs 6a-l)

A 19 year old patient presented with a Class II malocclusion (~5mm bilaterally) with a large overjet (~8mm) and moderate overbite (4-5mm). IZC 6 screws (2x12mm SS) were placed bilaterally to retract the entire upper dentition, to treat the Class II discrepancy without extractions. In addition, a 2x8mm SS bone screw was placed apically between the maxillary central incisors to prevent extrusion of the anterior segment as the arch was retracted. The latter is a very important treatment planning consideration, because the line of retracting force from the IZC screws to the canines is occlusal to the center of resistance of the maxilla. The maxilla is expected to rotate posteriorly as the arch is retracted, so an intrusive force on the anterior segment is essential to prevent producing a gummy smile.

Following 13 months of upper arch retraction (19y1m to 20y2m) the right buccal relationship was corrected to Class I, but the left side was still Class II and the upper midline was deviated ~4 mm to the right. CBCT imaging was indicated to investigate the problem. The 3D views revealed that the right IZC 6 was not in contact with the roots of any teeth and further retraction of the maxillary arch was possible. However, on the left side, the tip of the IZC 6 was in contact with the distal surface of the U6 MB root, preventing the retraction of the buccal segment.

The left IZC 6 was removed and an IZC 7 screw (2x12mm SS) was placed.

Following 5 months of additional retraction (from 20y3m to 20y8m), the upper midline was still deviated to the right and the left buccal occlusion remained Class II. Another CBCT was used to investigate the continuing problem. There was adequate root clearance for the left IZC 7, but there was a concavity on the U6 MB root, and obliteration of the periodontal ligament (PDL), which was consistent with ankylosis.⁷



■ Fig. 6a:

Case 2 is a patient with a bilateral Class II malocclusion and a large overjet.

■ Fig. 6b:

Case 2. After 13 months of maxillary retraction with IZC 6 anchorage, the upper midline is off to right because the right side is being retracted, but the left side is not moving.



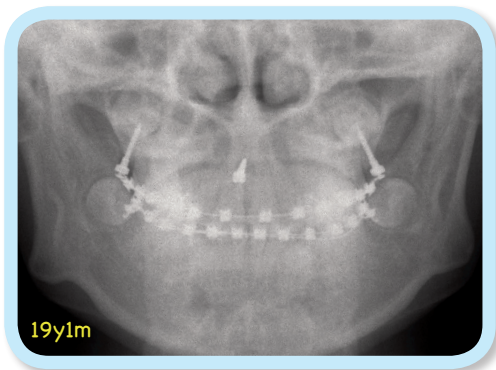
■ **Fig. 6c:**

Case 2. After 13 months of retraction, the right side is corrected, but the left side has failed to move.



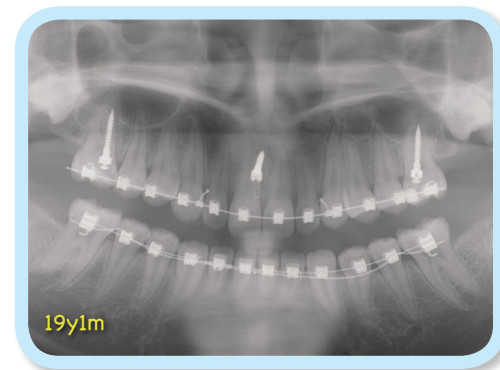
■ **Fig. 6d:**

Case 2. A lateral cephalometric radiograph shows a large overjet at the start of treatment.



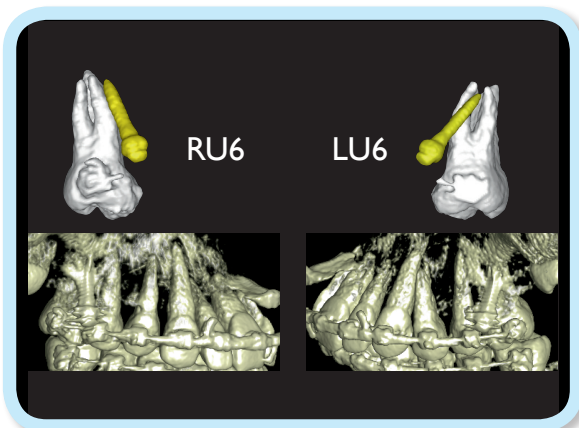
■ **Fig. 6e:**

Case 2. A frontal (PA) cephalometric view shows the orientation of the IZC 6 screws at the start of treatment.



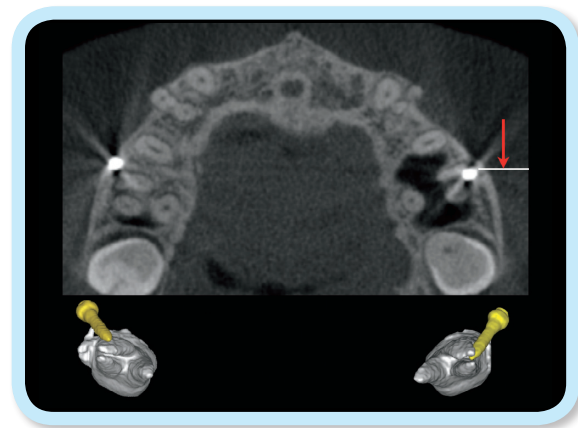
■ **Fig. 6f:**

Case 2. The panoramic view at the start of treatment suggests that the right IZC 6 screw is on the buccal side of U6 MB root, while the left IZC 6 screw is on the distal side of U6 MB root.



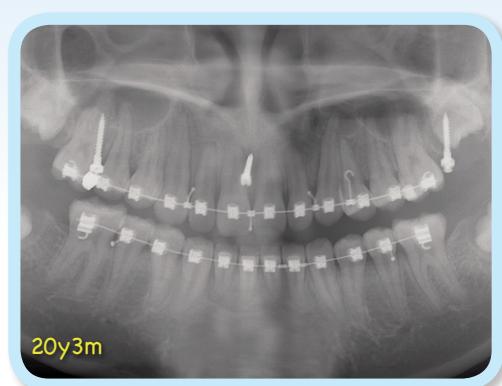
■ **Fig. 6g:**

Case 2. CBCT imaging shows that the right IZC 6 screw is on the buccal side of right U6 MB root. The left IZC 6 is on the distal side of U6 MB root. The upper 3D renderings are courtesy of Dr. Bryan PJ Kuo.



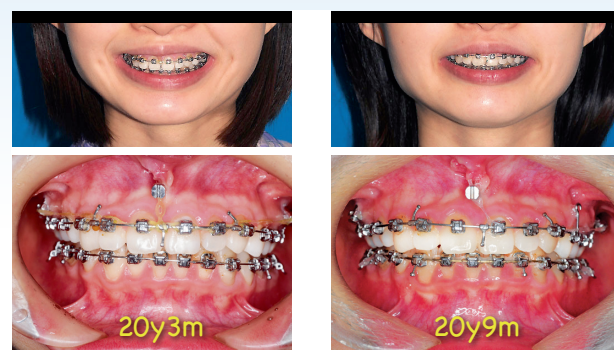
■ **Fig. 6h:**

Case 2. The CBCT axial view and 3D rendering shows that the right IZC 6 is in front of U6 MB root, which allowed maxillary retraction on the right side. However, the left IZC 6 is impinging on the U6 MB root preventing maxillary retraction on the left side.



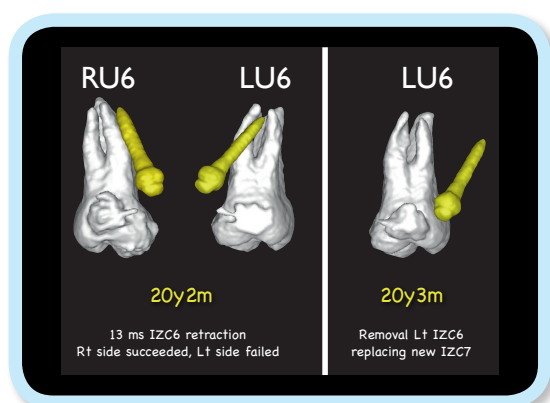
■ Fig. 6i:

Case 2. A postoperative panoramic radiograph shows the position of the new left IZC 7.



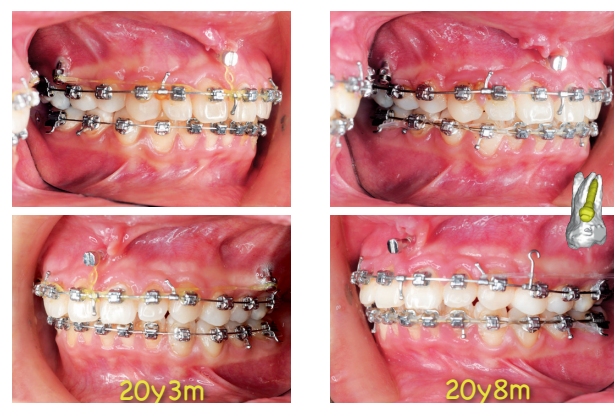
■ Fig. 6j:

Case 2. After 6 months of additional maxillary retraction, the upper midline was improved but still slightly off to right.



■ Fig. 6k:

Case 2. On the left, a 3D rendering at 20y2m shows the right IZC 6 was in front of U6 MB root, so retraction occurred as planned, but the left IZC 6 impinged on the left U6 MB root and prevented retraction. On the right, a 3D rendering at 20y3m shows that the IZC 6 screw was removed and a new IZC 7 screw was in place. Note that there is a depression on the MB root, which may be where the LU6 became ankylosed. (Courtesy of Dr. Bryan PJ Kuo)



■ Fig. 6l:

Case 2. Five additional months of traction with the new IZC 7 screw failed to result in retraction of the maxillary arch on the left side. It is hypothesized that the traumatized UL6 had become ankylosed.

It was concluded that the initial attempt to retract the maxilla on the left side damaged the left U6 MB root, leading to PDL damage and ankylosis. In general, complications and failures with IZC screws are more common on the left side for right-handed clinicians.⁸ All three problem cases in the current report are consistent with this trend: Case 1 & 2 an IZC 6 screw contacted the distal surface of an U6 MB root, precluding retraction of the maxillary segment. Case 3 an IZC 7 screw contacted the distal surface of an U7 MB root, precluding retraction of the maxillary segment.

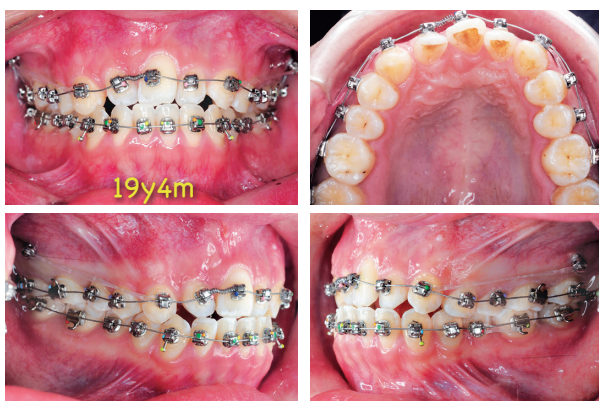
What has been learned from this case?

When placing IZC 6 screws it is important to avoid contacting the distal root surfaces of any teeth in the buccal segment. Right handed clinicians must be particularly careful with screw placement on the left side, and vice versa. Contacting the distal surface of U6 MB root prevented the dentition from further retraction. Furthermore, ankylosis of the damaged U6 MB root continued to prevent left segment retraction, even after a suitable IZC 7 screw was installed.

Case 3 (Figs 7a-k)

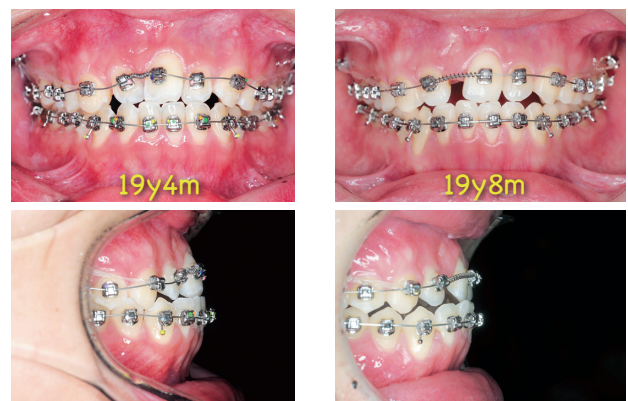
A 19 year old patient had a modest asymmetric Class II malocclusion with an impacted right central incisor (UR1). An acquired malocclusion had developed in the maxillary anterior segment. The adjacent incisors drifted into the edentulous UR1 space, and tipped lingually creating an anterior crossbite and severe space deficiency. To open the UR1 space without flaring the maxillary anterior dentition, two IZC 7 screws were placed to provide a distal force on the maxillary canines to prevent anterior protrusion as the UR1 space was opened.

After 4 months of bimaxillary canine retraction (19y4m to 19y8m), the right buccal segment was overcorrected to super Class I, but the left side was still in the original Class II relationship. A CBCT was indicated to evaluate the positions of the IZC screws. The 3D image of the left buccal segment showed that the tip of 12mm IZC 7 was distal to the U7 MB root, preventing buccal segment retraction. Since SS screws are not expected to osseointegrate,⁵ their mechanical retention is primarily related to cortical bone engagement. Cortical bone thickness in the posterior maxilla is ~1.2-1.3mm⁹ and the attached gingiva is about 1.25 mm thick,¹⁰ so an



■ Fig. 7a:

Case 3 shows the start of treatment for a patient with an impacted right maxillary central incisor (UR1). Bimaxillary retraction of the maxillary buccal segments was planned using IZC 7 screws.



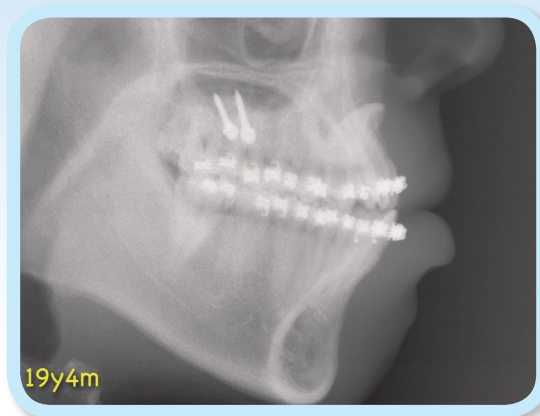
■ Fig. 7b:

Case 3. After 4 months of retraction, the upper midline was still ~5 mm off to right.



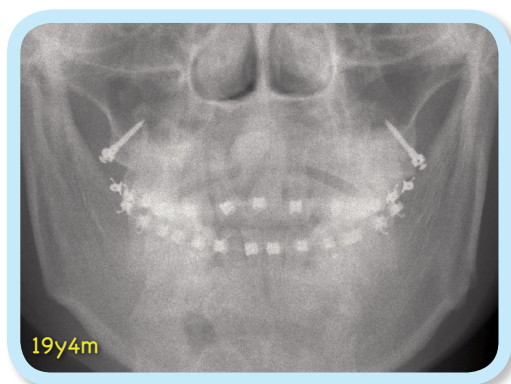
■ Fig. 7c:

Case 3. Right side had been overcorrected to super Class I, but the left side has failed to move.



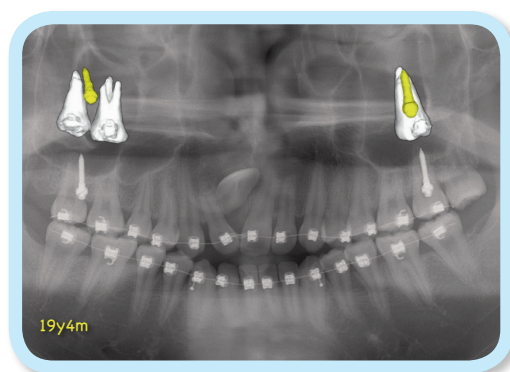
■ Fig. 7d

Case 3. A lateral cephalometric radiograph reveals that the UR1 is impacted and has a dilacerated root.



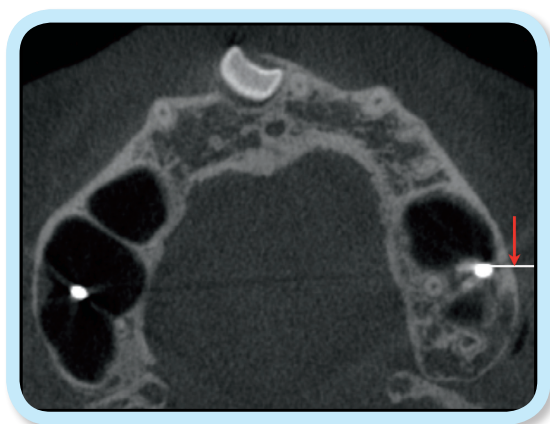
■ Fig. 7e:

Case 3. A frontal (PA) cephalometric radiograph shows the orientation of the IZC screws.



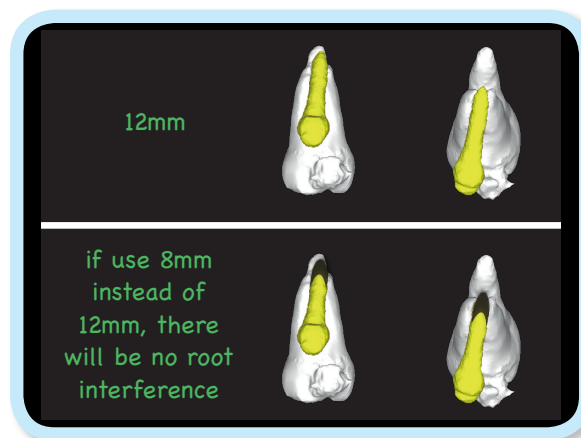
■ Fig. 7f:

Case 3. Bilateral IZC 7s were placed. The right IZC 7 was over the buccal surface of right U7 MB root. The left IZC 7 was over the distal surface of U7 MB root.



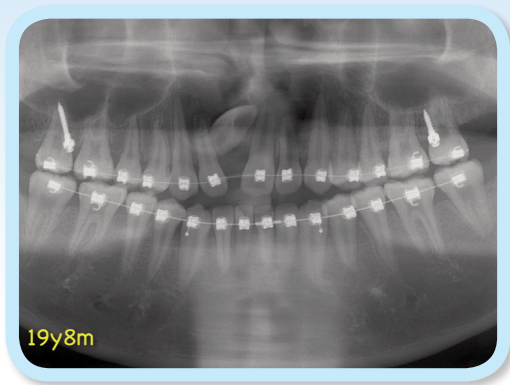
■ Fig. 7g:

Case 3. A CBCT axial view reveals that the tip of the left IZC 7 screw impinged on the root of the left U7 MB root preventing maxillary retraction on the left side.



■ Fig. 7h:

Case 3. 3D CBCT renderings show that the left 12mm IZC 7 screw impinged on the left U7 MB root. If an 8mm screw had been used instead, there would have been no root interference. (Courtesy of Dr. Bryan PJ Kuo)



■ **Fig. 7i:**

Case 3. A panoramic radiograph shows an original 12mm IZC 7 screw on right side with a new 8 mm IZC 7 screw on the left side.



■ **Fig. 7j:**

Case 3. After 4 months of traction with the new left IZC 7, the upper midline was corrected.



■ **Fig. 7k:**

Case 3. After 4 months of traction with the new left IZC 7, the Class II left buccal segment has been corrected to Class I.

8 mm screw would provide adequate osseous anchorage for mechanical retraction of the buccal segments.

To correct the problem for *Case 3*, the 12mm IZC 7 screw was removed and a 2mm x 8mm IZC 7 screw was placed in an adjacent site. Following 4 more months of retraction, a Class I occlusion was achieved on the left side and the maxillary midline was corrected.

What has been learned from this case?

Although there is thicker buccal bone at the IZC 7 site, a 12mm screw is of sufficient length to strike the roots of the molar and prevent buccal segment retraction. If the screw length is reduced to 8 mm, the chance of root interference is substantially reduced.

Discussion

The timely diagnosis of arrested maxillary posterior segment retraction is an important consideration when using IZC anchorage. The root interference problem for *Case 1* was diagnosed after 9 months. The screw was replaced and the continued retraction of the upper dentition was successful, but the overall treatment time was unnecessarily lengthened. For *Case 2*, retraction was attempted for 13 months before the root interference problem was suspected, and unfortunately iatrogenic ankylosis occurred which prevented further tooth movement. On the other hand, the retraction problem for patient 3 was diagnosed after only 4 months, and immediately corrected. The first two patients would have benefitted from a more timely diagnosis of the root interference problem. Based on this clinical experience, it is recommended that retraction

of buccal segments with IZC anchorage be carefully evaluated. If there is no clinical movement of the maxillary relative to the mandibular arch after ~5 months, a CBCT is indicated to determine if the IZC screw is interfering with the molar roots.

To avoid root interference, the IZC 7 site is superior to the IZC 6 site because the buccal plate of bone is thicker. Furthermore, decreasing the screw length from 12 to 8 mm screw further diminishes the risk of screw interference with tooth roots. The 8mm screw is now routinely recommended for the IZC 7 application if the head of the TAD (*platform*) is screwed into contact with the gingiva. However, if a 2-3mm gap is desirable, between the soft tissue and the platform of the screw, a 10mm TAD may be preferable.

Overall IZC 7 site is superior to the original IZC 6 location, and the following procedure is recommended. Under local infiltration anesthesia, the 2x8mm SS self-drilling screws are inserted perpendicularly into the bone about the level of muco-gingival junction buccal to the second molar roots and then rotated ~55-70 degrees and the TAD is screwed in (*Fig. 2*). If a screw contacts a tooth root, even an anesthetized patient will feel some pain. In that event, the screw is removed and inserted in a new position that is not painful. Follow-up CBCT images of IZC 7 screws have failed to demonstrate any root injuries, but occasionally a close contact of the screw with the root has been noted. However, less IZC 7 screws have been placed between the roots of teeth, so that they interfere with retraction of the entire maxillary arch. Since the goal for full arch retraction is to place the screw outside the inter-radicular area, decreased screw length and the thicker plate of buccal bone at the IZC 7 site are major advantages.

Conclusion

- The IZC 7 site is an easier and safer location for screw placement because the buccal bone plate is thicker, compared to the IZC 6 site.
- A 2x8 mm SS screw in the IZC 7 site, with the platform in close contact with the gingiva, is adequate anchorage for retracting the entire maxillary arch. The shorter screw rarely interferes with the molar roots.
- Inserting an IZC screw under local anesthesia provides safe and effective osseous anchorage.
- When placing either IZC 6 or IZC 7 screws, try to position the tip of the screw anteriorly to the MB root of the respective molars to facilitate retraction of the maxillary dentition.
- Even when screw to root contact prevented whole arch retraction, the screws were still firm could still be used as anchorage for extraction cases.

- When using IZC 6 or IZC 7 screws for anchorage to retract the maxillary arch, regularly monitor progress. If maxillary arch retraction is slow or arrested, investigate the problem with CBCT 3D imaging. If there is root interference, remove the screw and replace it with a shorter screw in another location, as indicated.

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