

An unusual case of invasive cervical resorption after piezosurgery-assisted en masse retraction

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A 16-year-old patient sought orthodontic correction for profile improvement and labially inclined maxillary incisors. She had Class II malocclusion, protrusive maxillary and mandibular incisors, and increased overjet and overbite with an American Board of Orthodontics discrepancy index value of 25. She was treated with maxillary premolar extractions and miniscrew-supported en masse retraction assisted with piezoincisions. Extraction spaces (7.5 mm per side) were closed with maximum anchorage in 10 months. Total treatment time was 23 months. Twenty-seven months after debonding, a pink spot was noted at the buccocervical region of the left central incisor. Radiographic evaluation on cone-beam computed tomographic scans revealed a severe case of invasive cervical resorption on both central incisors, around which the piezosurgical cuts had been made. Treatment proceeded with a nonintervention approach and the affected teeth were reinforced with a lingual retainer. (*Am J Orthod Dentofacial Orthop* 2019;156:137-47)

Rapid orthodontic tooth movement is a widely investigated subject in the orthodontic practice. Among the great variety of approaches, piezoincision is one of the surgery-assisted techniques of a minimally invasive nature.^{1,2} Some of the cases treated with piezoincision-assisted orthodontics are canine distalization, en masse retraction, incisor decrowding, compensation of Class II and Class III malocclusions, and expansion.³⁻⁸

Invasive cervical resorption (ICR) is a type of external root resorption that starts beneath the epithelial attachment and progresses toward the pulp chamber, which then changes direction apically and coronally once it reaches the predentin.⁹ It circumvents the pulpal tissue and spreads in all 3 dimensions in a nontraditional way. ICR may present itself as a cavitation at the cemento-enamel junction level, an irregularity in the gingival contour, or a pinkish color change due to the

reflection of the rich vasculature under the resorbed enamel. This type of external resorption is often silent because the pulp is protected by a pericanalar resorption-resistant layer which ensures that electric and thermal pulp tests remain positive until advanced stages.^{10,11} This explains why ICR is usually detected incidentally during routine radiographic examination or occasionally by the pink spot on the crown.^{12,13} Etiologic factors include orthodontic treatment, surgical interventions, inflammation, and trauma, as well as idiopathic factors.^{9,14,15} The most commonly affected teeth are maxillary central incisors, accounting for 30.4% of all the reported ICR cases.¹⁶

The longstanding ICR classification of Heithersay¹⁷ defines classes I and II to represent lesions limited to the crown with shallow penetration and closer proximity to the coronal pulp, respectively. Classes III and IV, on the other hand, demonstrate deeper invasion of the lesion with more apical extension. This classification has a critical shortcoming of overlooking the buccolingual aspect of the lesion because it was developed by using 2-dimensional periapical radiographs.^{18,19} Recently Patel et al²⁰ introduced a new 3-dimensional classification that includes the height, circumferential spread, and proximity of the lesion to the root canal. According to this new classification, height of the lesion is its maximum vertical extent (graded from 1 to 4), and can be best assessed on coronal and sagittal cone-beam computed tomographic (CBCT) images. Circumferential spread

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Fig 1. Pretreatment extraoral and intraoral photographs.

gives the amount of circumscription by degrees (from A to D), and proximity to the root canal shows whether the lesion is confined to dentin (d) or involved with the pulp (p). Both circumferential spread and proximity are best assessed on axial CBCT images.

The aim of this case report is to present a case of ICR after piezoincision-assisted en masse retraction.

DIAGNOSIS

A 16-year-old female patient had chief complaints of unpleasing profile and labially inclined upper incisors. She had Class II malocclusion with increased overjet (7.5 mm) and overbite (5.6 mm). Lower dental midline was mildly shifted to the left. Clinically, she had a convex profile and a deep mentolabial fold (mentolabial angle 101.1°). Lower lip was protrusive and everted. Strain was noted on the upper lip on lip closure (Fig 1).

According to dental casts analysis, 0.6 mm maxillary and 3.5 mm mandibular arch discrepancies were present, with 2.9 mm lower anterior Bolton excess.

Cephalometric analysis showed that she had a skeletal Class 2 relationship (ANB 6.3°) with an ideally positioned maxilla (SNA 81.9°) and a retrusive mandible (SNB 75.6°). Both upper and lower incisors were proclined (U1.HRP 118.3° , L1.GoMe 102.2°). Clinical and radiographic examination revealed discoloration and root canal filling in the upper right second premolar (Fig 2; Table). The American Board of Orthodontics Discrepancy Index²¹ score was 25 (Supplementary material, available at www.ajodo.org).

TREATMENT OBJECTIVES

Treatment objectives were to improve facial and profile esthetics, reduce overjet and overbite, obtain

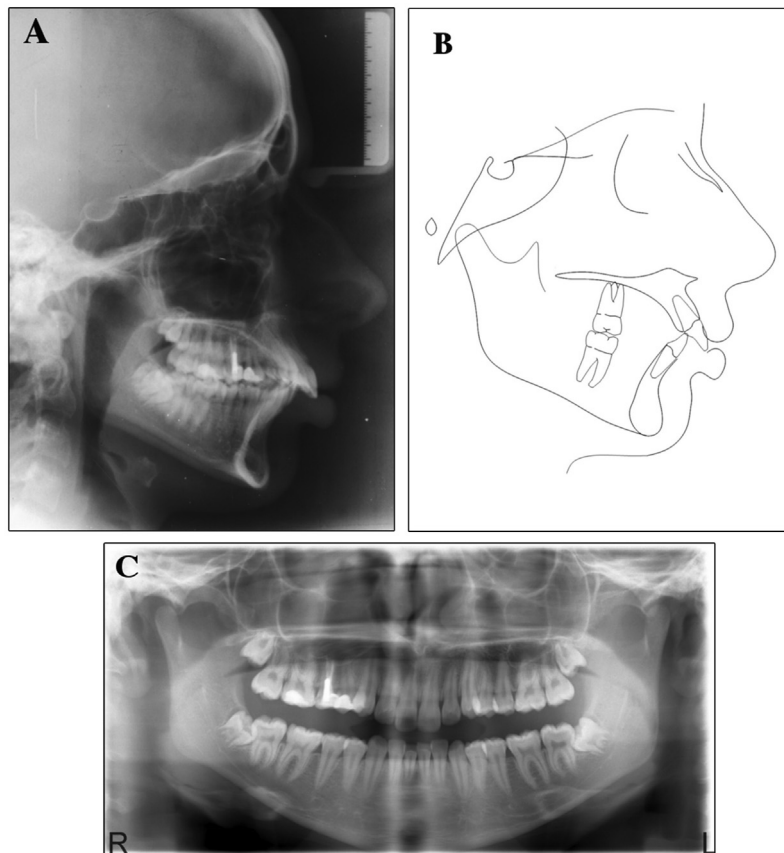


Fig 2. A, B, Pretreatment lateral cephalometric film and tracing; C, panoramic radiograph.

ideal upper incisor inclination, prevent further lower incisor proclination during leveling, correct lower midline deviation, and achieve Class I canine occlusion.

TREATMENT ALTERNATIVES

Three treatment alternatives were offered to the patient. The first was to perform mandibular advancement surgery for a significant improvement in the facial profile. The second was to distalize the maxillary dental arch with the use of temporary anchorage devices (TADs) placed below the zygomatic crest and reduce overjet by means of dental camouflage. The third was to extract 2 upper premolar teeth and perform miniscrew-supported en masse retraction. With this treatment approach, it was also aimed to intrude upper incisors by placing the miniscrews in a more apical position than the power hooks.

The patient asked for the third alternative and we offered her a combination treatment with piezoincisions to attempt to achieve rapid tooth movement.

Treatment progress

Unlike the conventional extraction approach, the upper right second premolar with root canal treatment and the left first premolar were extracted. Brackets and tubes (Victory Series; 3M Unitek, Monrovia, CA) with MBT prescription and 0.018 × 0.025-inch dimension were used. In the session when the maxillary dental arch was fully leveled and aligned, miniscrews with 1.5–1.4 mm diameter and 7 mm length (AbsoAnchor; Dentos, Daegu, Korea) were placed mesial to the upper first molar roots. Posterior segments of a 0.016 × 0.022-inch stainless steel archwire was rounded and polished to reduce friction. Nickel-titanium closed coil springs exerting 225 g of force per side (Ormco Corp, Orange, CA) were attached between miniscrews and power hooks (7 mm; Ortho Organizers, Carlsbad, CA) that were placed distal to the lateral incisors (Fig 3).

At the same session when en masse retraction mechanics were put in place, piezoincisions (VarioSurg; NSK, Hoffman Estates, IL) were performed under local anesthesia and coolant irrigation. After soft tissue incisions, 3 mm long and 3 mm deep piezosurgical cuts

Table. Cephalometric measurements at the beginning of treatment (T1), at the end of treatment (T2), and changes with treatment (T2-T1)

| Measurement | Norm | T1 | T2 | T2 – T1 |
|----------------------|---------------|---------|---------|---------|
| Skeletal | | | | |
| SNA | 80° ± 2° | 81.9° | 80.2° | -1.7° |
| SNB | 78° ± 2° | 75.6° | 75.5° | -0.1° |
| ANB | 2° ± 2° | 6.3° | 4.7° | -1.6° |
| VRP-A | | 67.7 mm | 66.3 mm | -1.4 mm |
| Wits | 0 ± 1 mm | 7.1 mm | 5.4 mm | -1.7 mm |
| GoGn.SN | 32° ± 6° | 32° | 33.4° | 1.4° |
| ANS-Me | | 61.5 mm | 63.5 mm | 2 mm |
| Dentoalveolar | | | | |
| U1.HRP | 116° ± 5.5° | 118.3° | 108° | -10.3° |
| U1i-VRP | | 74.9 mm | 69.7 mm | -5.2 mm |
| U1a-VRP | | 64 mm | 62.1 mm | -1.9 mm |
| U1i-HRP | | 69.5 mm | 67.2 mm | -2.3 mm |
| U1a-HRP | | 48.8 mm | 44.2 mm | -4.6 mm |
| L1.GoMe | 90° ± 3° | 102.2° | 102.3° | 0.1° |
| L1-NB | 4 mm | 8.4 mm | 8.2 mm | -0.2 mm |
| L1-NB | 22° ± 5° | 32.6° | 33.2° | 0.6° |
| Overjet | 2 ± 1 mm | 7.5 mm | 2.5 mm | -5 mm |
| Overbite | 2 ± 1 mm | 5.6 mm | 2.7 mm | -2.9 mm |
| Soft tissue | | | | |
| UL-VRP | | 85.2 mm | 82.9 mm | -2.3 mm |
| Upper lip thickness | 12.6 ± 1.8 mm | 10.4 mm | 12.2 mm | 1.8 mm |
| LL-VRP | | 81.4 mm | 79.6 mm | -1.8 mm |
| Nasolabial angle | 85° – 105° | 109.9° | 113.5° | 3.6° |
| Mentolabial angle | 107° – 118° | 101.1° | 114.3° | 13.2° |

HRP, Horizontal reference plane, a horizontal plane angulated 7° clockwise to the sella-nasion plane at sella; VRP, vertical reference plane, a perpendicular plane to the HRP passing through sella.

were made between each neighbouring tooth root and distal to right premolar and left canine roots at the middle third level (surgery mode, program #5, 70% power) (Fig 3).

To avoid further lower incisor proclination during leveling, interproximal reduction was performed on the lower anterior teeth in the limits of Bolton excess.

Treatment results

Posttreatment photographs show improved profile esthetics, better lip closure and lower lip posture with good intercuspitation (Fig 4). Through the treatment period, upper incisors tipped palatally for 10.3°, and incisal edge and apical point moved palatally for 5.2 mm and 1.9 mm, respectively, showing a combination of controlled tipping and parallel tooth movement. As the result of incisor retraction, A point moved backwards and induced a decrease in the SNA and ANB angles simultaneously. The vertical component of the retraction force resulted in 2.3 mm incisal and 4.6 mm apical intrusion which contributed to reduction of the overbite. Meanwhile lower incisor inclination was

preserved. Overjet decreased from 7.5 mm to 2.5 mm, and overbite decreased from 5.6 mm to 2.7 mm. The mentolabial angle increased by 13.2° with upper incisor retraction and elimination of lower lip eversion. Lower dental midline deviation was corrected to meet the facial midline (Figs 5 and 6; Table).

The extraction spaces (7.5 mm on both sides) were fully closed in 10 months with maximum anchorage. Total treatment time was 23 months. Upper 4-4 and lower 3-3 retainers were bonded at the end of the treatment. Blunting of the roots was indicative of orthodontically induced external root resorption; however, no visible signs of ICR were evident on the panoramic radiograph at the end of the treatment (Fig 5). The patient was advised to have her third molars extracted.

Twenty-seven months after debonding, a pink spot could be seen at the buccocervical region of the left central incisor. After taking a preliminary periapical radiograph, an irregular radiolucency on the cervical third of the left central incisor root was identified (Fig 7). Further radiographic evaluation on CBCT scans confirmed ICR on both central incisors (Fig 8).

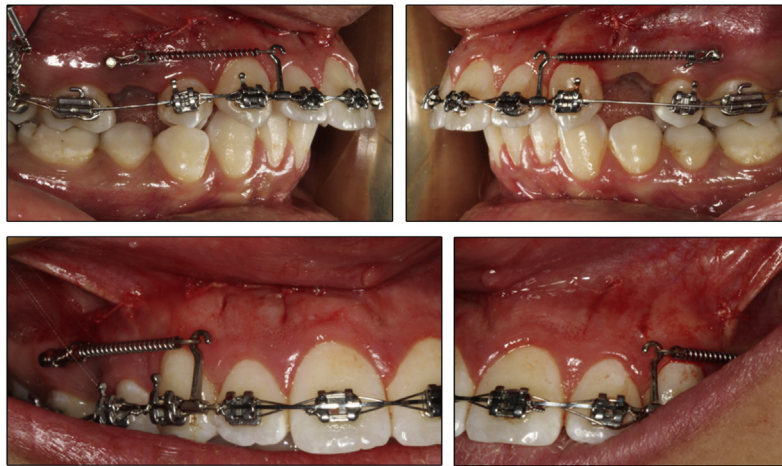


Fig 3. Miniscrew-supported en masse retraction mechanics and piezosurgical cuts.



Fig 4. Posttreatment extraoral and intraoral photographs.

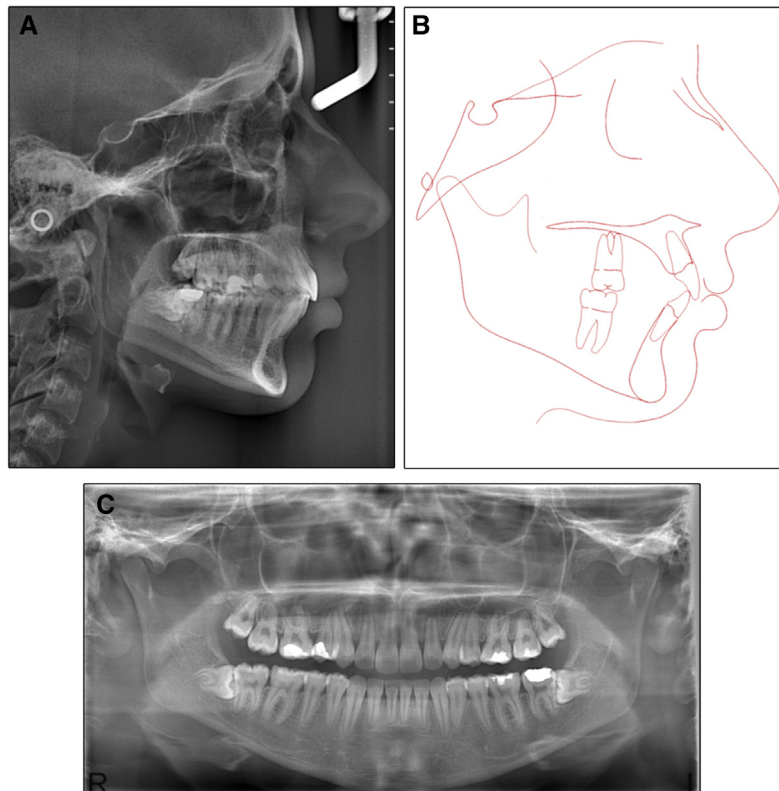


Fig 5. A, B, Posttreatment lateral cephalometric film and tracing; **C,** panoramic radiograph.

According to Heithersay's classification,¹⁷ both upper central incisors presented grade 4 ICR. Considering Patel et al's classification,²⁰ the height of the lesion extended to the apical third of the root in both incisors, the circumferential spread was more than 270° for the right central incisor and between 90° and 180° for the left central incisor. The lesion was confined to dentin in the right central incisor, and there was a probable pulpal involvement in the left central incisor.

After diagnosis, the plan was to monitor the teeth and proceed with a nonintervention approach. A new lingual retainer was fabricated to support the affected teeth against occlusal forces. She was also instructed to avoid biting food with her incisor teeth. The possibility of placing dental implants was explained if by any chance the crown fractured.

DISCUSSION

ICR is a silent yet aggressive type of external root resorption. Numerous factors are held to be responsible for the etiology of ICR, 2 of which are orthodontic treatment and surgical intervention.^{17,22,23}

This raises concern about whether patients undergoing surgery-assisted orthodontic treatment for accelerated tooth movement are at higher risk for ICR. Therefore, the aim of this case report was to point out a possible etiologic combination for ICR in a case treated with piezoincision-assisted en masse retraction.

For ICR to begin, local damage and subsequent healing process should take place at the periodontal ligament, populating the wounded area with macrophages.²⁴⁻²⁶ Piezoincisions could be the local detrimental factor that surgically insulted the periodontal tissues in our patient. Also, a stimulating factor such as infection or continuous mechanical force would be present, and in this case orthodontic retraction force met that need.²⁵ In the presented case, upper anterior teeth were exposed to a total of 450 g of force for 10 months. Furthermore, miniscrews were used to prevent molar mesialization and the posterior section of the archwire was rounded to minimize the friction between archwire and posterior bracket slots, both of which contributed greatly to preserve the force directed to the anterior unit.²⁷ Moreover, incisors were exposed to retraction forces for a longer

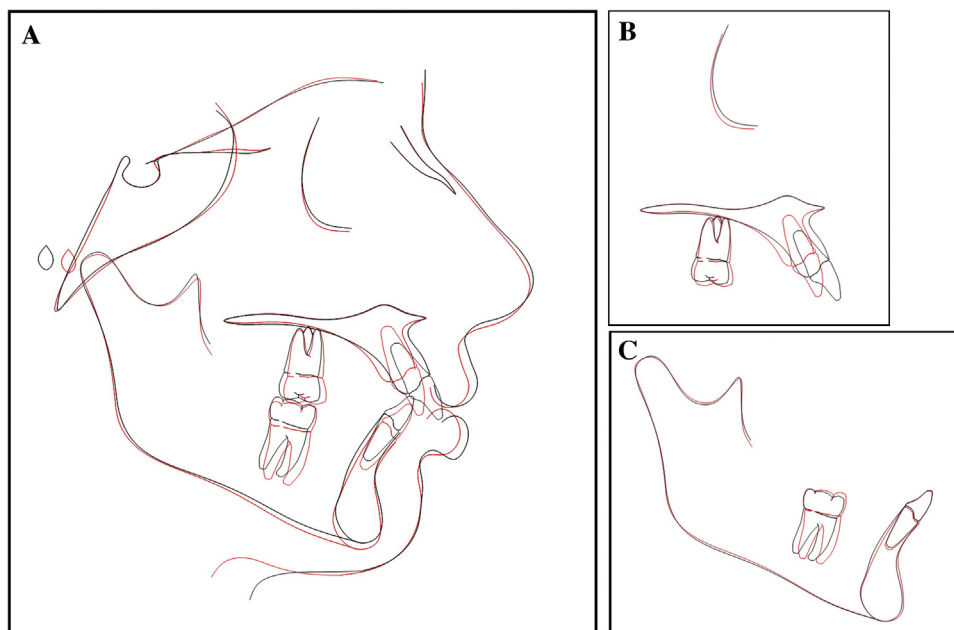


Fig 6. Pretreatment (*black line*) and posttreatment (*red line*) superimposition of cephalometric tracings: **A**, cranial base superimposition on sella; **B**, maxillary superimposition using ANS-PNS plane (on ANS); **C**, mandibular superimposition using mandibular plane (on menton). Note the amount of intrusion and retraction of upper incisors ($\Delta U1i\text{-HRP} -2.3$ mm, $\Delta U1a\text{-HRP} -4.6$ mm, $\Delta U1i\text{-VRP} -5.2$ mm, $\Delta U1a\text{-VRP} -1.9$ mm, $\Delta U1\text{-HRP} -10.3^\circ$), and the change in A point ($\Delta V\text{RP-A} -1.4$ mm).

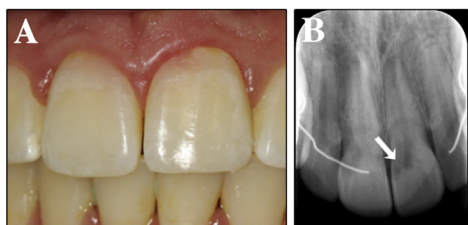


Fig 7. **A**, Pink spot under the gingival margin of upper left central incisor; **B**, periapical radiograph taken for preliminary examination.

period of time with en masse retraction compared with 2-step retraction where canines and incisors are retracted separately, as well as because extraction spaces were closed solely by means of anterior retraction. Therefore, we think that the anterior teeth but especially the central incisors were exposed to heavy orthodontic forces for a long time which may have triggered external root resorption at the cervical region. Another prerequisite for the initiation of ICR is the disruption of the integrity of the cementum, as in a cemental tear or traumatic damage resulting in an altered root surface, thereby making it vulnerable to resorbing clastic cells.^{28,29} The surgical procedure may have created a

susceptible root surface by direct mechanical trauma to the root surface during surgery or by increasing odontoclastic activity.^{30,31}

According to the researchers such as Köle,³² Suya,³³ and Iino et al,³⁴ corticotomy decreases the risk of hyalinization and root resorption by reducing the resistance against tooth movement. In contrast, histologic studies show that a local trauma to the bone or periodontal ligament increases the concentrations of the receptor activator of nuclear factor κB ligand, macrophage colony-stimulating factor, and other inflammatory cytokines, which stimulates the differentiation of not only osteoclasts but also odontoclasts.^{30,35-40} This is probably the most notable finding explaining the possible mechanism of root resorption after surgery-assisted techniques as well as the one that clinicians are advised to keep in mind to avoid iatrogenic root resorption. In accordance with this finding, a controlled study investigating the effect of piezosurgery on root resorption with the use of microcomputed tomography showed that orthodontic buccal tipping force combined with piezosurgery resulted with 44% more root resorption than orthodontic force itself, and the difference was statistically significant.³¹ The authors explained this finding with the increased local inflammatory response and bone turnover rate triggered by the

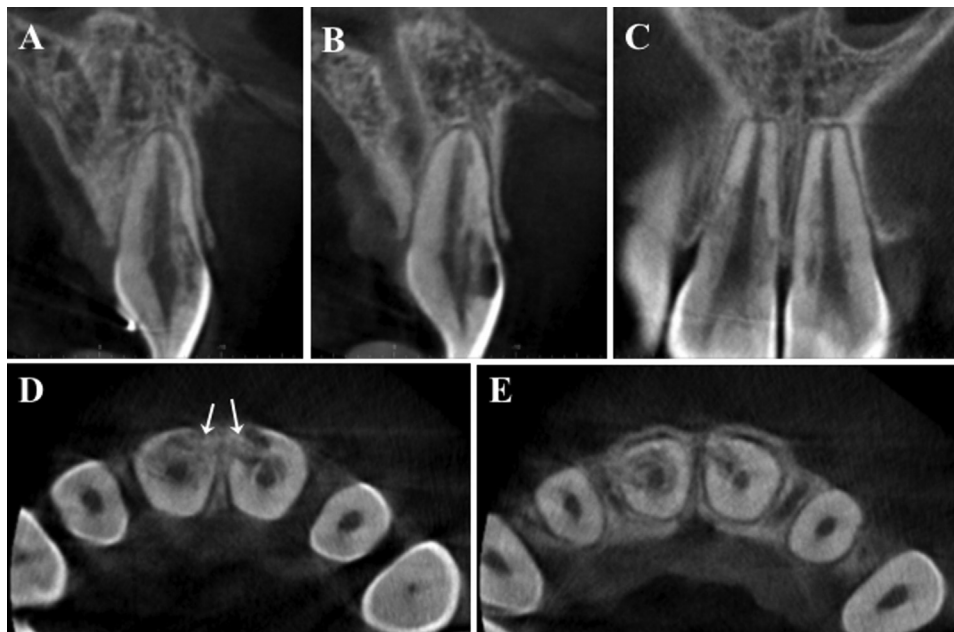


Fig 8. Sagittal slice showing **A**, upper right central incisor and **B**, upper left central incisor; **C**, coronal slice showing both upper central incisors; **D**, axial slice taken at the cemento-enamel junction level, *arrows* indicating portals of entry and reparative calcified tissue; **E**, axial slice taken 2 mm apical to the cemento-enamel junction level.

surgical insult.^{30,31,41} They also stated that some of the experimental teeth were directly damaged during the surgical procedure. These findings place emphasis on the importance of presurgical evaluation and planning regarding the design and extent of the piezosincisions, and even fabrication of guiding splints, especially when the effect of piezosurgery is studied in crowding cases where the roots cannot be assumed to be parallel to each other.

Although piezosurgery is associated with increased root resorption, osseous outgrowths, and transitory bacteremia risk so far, ICR does not necessarily have to be the direct consequence of piezosurgery.^{31,42,43} If surgery that leads to increased turnover rate and recruitment of both odontoclastic and osteoclastic precursor cells trigger the pathology, then each and every surgery-assisted technique has equal potential to start ICR. Therefore, we think that ICR is not a technique-sensitive pathology and clinicians should be careful when deciding to perform any kind of surgical technique, not just piezosurgery.

Another explanation for the occurrence of ICR in this case could be the orthodontic malocclusion. Angle Class II Division 1 malocclusion is usually associated with dental trauma to the flaring upper incisors, which is considered to be a predisposing factor for ICR.^{9,14,44,45}

A former trauma incidence was reported with 29.1% of this kind of malocclusion, which tends to increase with age.⁴⁴ Although trauma was a valid reason, our patient did not have an upper incisor trauma history.

Radiographic evaluation performed on periapical radiographs tends to overlook the true dimensions of ICR lesions and miss the buccolingual aspect as the result of geometric distortion and anatomic superimposition.^{18,19,46-48} When decided to perform endodontic treatment, thoroughly removing the resorptive tissue becomes an important factor on the outcome of treatment and failure to identify the resorption channels extending incisopically can lead to recurrence.⁴¹ Also, it is critical to know the true extent of the lesion and the amount of the viable tissue present to treat the case effectively and to better judge what is worth treating and what is not. Today it appears that CBCT is the best method both to visualize and create an appropriate treatment plan for this complex and unpredictable pathology.^{19,39}

The treatment of ICR basically involves the mechanical or chemical elimination of the resorptive tissue and restoration of the resorption cavity. This inflammatory tissue can be eliminated with mechanical debridement or chemical removal with the use of trichloroacetic acid after flap reflection, orthodontic extrusion of the tooth to gain access to an apically positioned resorption

cavity, or extensive canal preparation during endodontic treatment.⁴⁹⁻⁵⁵ Treatment depends on the severity, location, pulpal involvement, and restorability of the tooth. Heithersay^{12,50} reported success rates of 100% for the treatment of class I and II ICR cases, and 77.8% for class III cases. He stated that the possibility of successfully treating a class IV case is as low as 12.5% and concluded that these cases would benefit more from extraction and restoration with the use of dental implants. Clement and Willemsen⁵⁶ also concluded that only limited areas of resorption with good surgical accessibility can be successfully treated because too much tooth material has often been resorbed at the time of screening. It is also emphasized in the literature that the imaging method used for diagnosis is another important determinant in treatment planning. Patel et al,¹⁶ in their study investigating the differences in detection, assessment, and management of ICR with the use of CBCT scans and periapical radiographs, showed that more teeth were deemed to be unrestorable when evaluated with the use of CBCT scans (78.7%) compared with periapical radiographs (49.3%). They stated that if the lesion is extensive and difficult to access, treatment might not always be possible and these teeth could require extraction or monitoring until symptoms arise or failure occurs. According to these researchers, meticulously executed diagnosis and treatment planning can save the patient from undergoing redundant procedures. For these reasons, and the fact that endodontic treatment would have worsened the already compromised dentinal walls and increased the risk of premature crown fracture, we decided not to treat the case, but to reinforce the effected teeth with a lingual retainer and to closely monitor them (Fig 8).

En masse retraction with maximum anchorage took 10 months and the retraction rate was 0.75 mm/month. Among the studies that reported retraction rates, ours falls within the range (0.51-0.85 mm/month) mentioned for miniscrew-supported en masse retraction without any intervention for rapid tooth movement.^{7,57} When the numbers are taken into consideration, it is fair to say that retraction rate did not show a substantial increase. This can be explained with the fact that the anterior unit in this patient was composed of 7 teeth, unlike conventional en masse retraction. Other reasons can be the malpositioned lower lip which rests in the overjet or an ongoing habit such as thumb-sucking, both of which physically constrain the anterior unit from moving palatally. Last but not least, as was recently shown in a randomized controlled study, piezoincisions may simply be inefficient in accelerating en masse retraction.⁷

Miniscrews offer the opportunity to design effective retraction mechanics to treat the orthodontic problem 3-dimensionally.⁵⁸ In a case with flaring upper incisors and deep bite, extraction therapy is usually avoided in an attempt to keep the overbite within the normal range for an ideal anterior occlusion. However, the vertical component of miniscrew-supported en masse retraction force helps to keep the incisors in their original vertical position and even reduces the overbite with further incisor intrusion.^{7,58} Studies in the literature report up to 2.2 mm incisor intrusion with this technique, which was 2.3 mm in our patient.^{7,58,59} As a matter of fact, the amount of pure intrusion is even more than the overall 2.3 mm upward incisal movement, when deepening of the overbite during retraction is taken into account. This can be supported with the difference between the amount of incisal (2.3 mm) and apical intrusion (4.6 mm). Miniscrew-supported en masse retraction has also proven to be effective in reducing subnasal prominence by changing the position of the A point.^{7,60} Subtle arrangements in power hook length and vertical positioning of the miniscrews help to create a closer retraction force to the center of resistance compared with conventional retraction mechanics. As a consequence, incisor roots retract more and the anterior wall of the maxilla remodels significantly.^{7,58} In our patient, A point moved 1.4 mm backwards and SNA angle decreased by 1.7° in response to 1.9 mm apical retraction (Fig 6). This is especially beneficial in cases with bimaxillary protrusion and Class II malocclusion with maxillary prognathia.

CONCLUSION

The risk of ICR may increase when surgery-assisted techniques are used with sustained heavy forces generated by orthodontic mechanics, such as en masse retraction, or in malocclusions requiring large orthodontic tooth movements. Therefore, exercising caution when using these techniques and monitoring the teeth carefully for ICR is advised.

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SUPPLEMENTARY DATA

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.ajodo.2019.02.012>.

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