A NOVEL TREATMENT APPROACH FOR EXTRUDED MAXILLARY MOLARS

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Abstract

Two approaches are currently used to correct overerupted/extruded posterior teeth, the "prosthodontic" and the "orthodontic" one. This report presents a novel orthodontic approach for selective molar intrusion.

In two females (26 and 20 years), a modified transpalatal arch (TPA, equivalent to a couple with a 30 g net force) was used to move the tooth bodily. A 50 g force was applied to the overerupted maxillary second molar by means of a short length elastomeric chain from the helix to the palatal sheath and replaced every three weeks. Sufficient intrusion of the maxillary second molar was obtained within two months.

For intrusion of a single tooth, a modified TPA together with a short length elastomeric chain is a non-invasive and cost-effective alternative to traditional edgewise mechanics, temporary anchorage devices, or removable appliances.

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Introduction

Unopposed molar teeth are frequently subject to overeruption, and are believed to be related to impaired masticatory function and to development of temporomandibular disorders.[1]

In a longitudinal study over 10 years with 12 adults, Christou and Kiliaridis found that unopposed molars showed more vertical displacement (0.8mm) than opposed molars (0.4mm). They concluded that the observed changes were either the result of late growth remodeling or a consequence of altered dental equilibrium following antagonist tooth loss.[2]

Two approaches are currently in use to correct overerupted (extruded) posterior teeth. The prosthodontic approach reduces the vertical height of the crown of the extruded tooth; however, depending on the amount of extrusion prior endodontic treatment might be necessary.

The orthodontic approach aims to intrude the tooth; however, due to the great root surface area of molars, the resistance to intrusion forces is high. A good anchorage system is necessary to counteract the unwanted effect of extrusion on the adjacent tooth. This report presents two cases successfully treated with an orthodontic approach using a modified transpalatal arch (TPA) for selective molar intrusion.

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Biomechanical Background

Intrusion is described as an apical movement in the direction of its long axis into the alveolus in the same direction that forces are imposed by physiologic occlusion by means of positive tension and positive pressure applied to the contents of the periodontal apparatus.

The periodontal ligament system is most resistant to orthodontic forces applied in vertical direction towards the apex of the root due to the unique combination of simultaneous hydraulic pressure and fibrous tension applied to the periodontal ligaments. Very light continuously applied forces are most effective. They result in small increases in fiber tension without elevating hydraulic pressures beyond the physiologic level and thus preventing the compressed tissues to be traumatized.[3]

Positive continued tension stretches the periodontal ligaments in a semi-elastic way. Small forces are required to maintain the extension until the fibers fatigue.[3] Positive pressure on the bone results in resorption. A continuous intrusive light force of 0.5N was also associated with significantly reduced basal blood flow in the pulp in 13 incisors ($p<0.05$).[4] After resorption of the bone, the tooth will move into the space closest to the tooth. The whole cycle is then repeated several times during orthodontic treatment.[3]

It is most important to know the center of resistance of the tooth to be intruded. This center is dependent on root length and morphology, number of roots and level of alveolar bone support. This center is usually located at about one-fourth to one-third the distance from the cemento-enamel junction to the root apex.[5] On upper incisors the center of resistance is located at 0.24 times the root length measured apically to the level of alveolar crest.[6]

Due to the delicate balance of the periodontal ligament fiber systems, the force applied needs to be well chosen, keeping in mind that these calculations are only approximate in individual cases. A force is equal to mass times acceleration ($F = ma$) and is measured either in Newton or clinically in gram x millimeter (mm). If the force passes through the center of resistance the tooth translates without tipping (so-called bodily movement). The further away the point of force application is from the center of resistance, the greater are the rotational and the linear moments; the rotation moment is to be determined by multiplying the magnitude of force by the perpendicular distance of the line of action to the center of resistance. The ratio between the net moment and net force on a tooth (M/F ratio) with reference to the center of resistance determines the center of rotation.[7]

An M/F ratio of 10:1 generally produces sole translation with the center of rotation located at infinity.[8]

The force presents magnitude (size) and direction and is described as a vector with a line of action and point of application. The magnitude of the moment force has 2 variables: the magnitude of the force and the distance from the center of resistance. Common ways of obtaining orthodontic forces are the deflection of wires, the activation of springs and auxiliaries such as elastics.[8]

An intrusive force on the molars' buccal tube creates a moment tipping the crown buccaly (Figure 1).

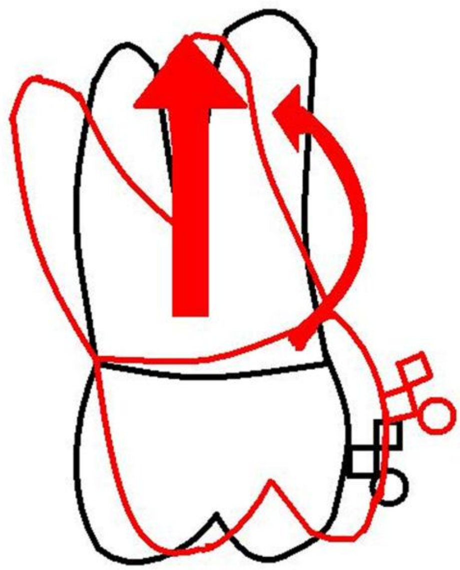

Figure 1. The intrusive force on the molar creates a moment tipping the crown buccaly.

An orthodontic force of higher magnitude will be required on molars than on incisors because of the larger area of periodontal attachment. There is a general agreement that this force should not exceed 100 gm.[9] Forces in conventional orthodontics are transmitted through the archwire. A very stiff archwire has a steep load-deflection curve with a high initial force that decays rapidly even with small tooth movements. The study by Kohno and co-workers suggests that molar movements induced by light forces with modern clinical appliances are close to physiological movements.[5]

Intrusion of a tooth will result in unwanted effects: (i) extrusion of the adjacent tooth, often seen when engaging an archwire while brackets height differs. This is associated with clockwise rotation of the mandible and an anterior open bite when the extrusion takes place in the molar area (Figure 2);[9] (ii) molar transversal width expansion when the intrusion is caused by a high pull headgear. This can be counteracted by constricting the inner bow of the high pull headgear or by using a TPA.[9]

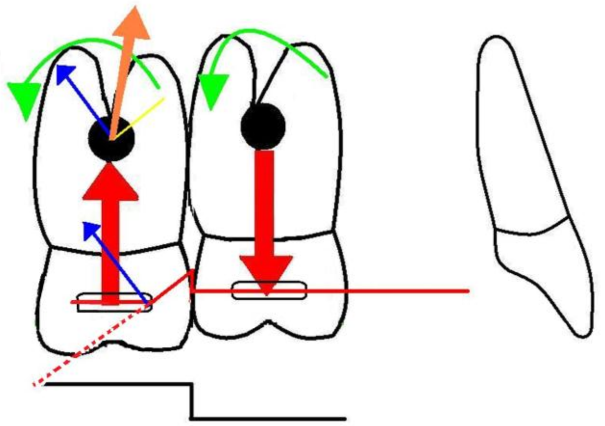

Figure 2. This step bend between the two terminal molars produces extrusion and lingual tipping of the first maxillary molar and intrusion combined with buccal tipping of the second maxillary molar. It does not only create couples in the same direction (green) but also distal tipping of the terminal molar with a 25° vertical force vector. Since the forces are applied to the buccal tube, it is important to compare equivalent force systems at the center of resistance in order to predict tooth movement. The resultant vector is indicated (orange). The unilateral extrusion of the adjacent maxillary first molar can cause an open bite if this unwanted effect is not sufficiently controlled.

This study proposes a different approach to molar intrusion and displays more anchorage than conventional biomechanics in which the risk of extruding the adjacent posterior tooth is prevalent. It can be considered a modification of previous designs, such as the Kucher and Weiland's appliance that uses similar biomechanics in combination with a transpalatal arch to reduce the prominence of the palatal cusp of the upper second molar.[18]

Materials and methods

Appliance fabrication & design: An impression was taken of the arch with the extruded molar. The teeth were bonded/banded with edgewise fixed appliances. A band was fit on the adjacent molar including a soldered palatal attachment for a prefabricated removable palatal bar (GAC International Inc., Islandia, NY).

The removable palatal bar was made of 0.036″ stainless steel round wire and was adjusted by cutting it in half and a helix was bent parallel to the roof of the palate. The removable palatal bar was then adjusted to a 60-90° angle so that the helix laid at the height of the center of resistance of the extruded molar. The helix was kept open facing the gingiva, just enough to activate the appliance by slipping through a power-chain or other elastomeric auxiliaries of choice. In combination with a main guiding stainless steel archwire 0.022″ or 0.022” x 0.028” (which is run through the buccal tube) a balanced force system was achieved to create an equilibrium between buccal and palatal root torque (Figure 3).

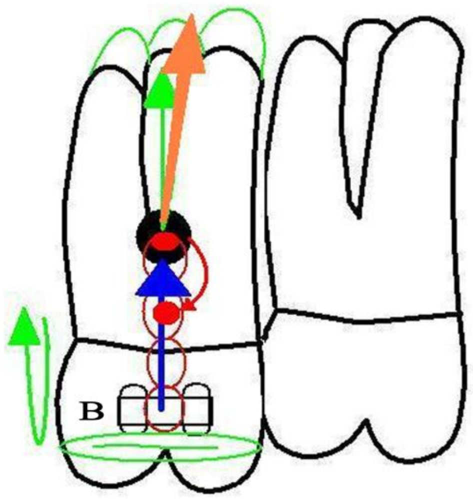

Figure 3 A. Palatal view of force system: At the palatal sheath (B) we connected an elastomeric auxiliary to the helix from the semi-palatal arch appliance (located at the height of the center of resistance to obtain pure translation). Note that during intrusion the height of the hook became more incisal and a couple is being created which brings the center of rotation from infinity toward the tooth. If this couple is large enough relative to the forces the amount of translation could become negligible in comparison to the tipping and the center of rotation would be near the center of resistance.

Forces: When representing a vector as an arrow, the point of application is indicated as the origin of the arrow and the length of the arrow is proportional to the magnitude of the force and is arbitrary. The arrowhead indicates the direction and the body indicates the line of action. All forces have the same scale. Our two applied forces acted on three planes of space as illustrated in the two-dimensional graph (Figure 2). To determine the single net force or resultant affecting the maxillary second molar, both applied net-effect forces had to be combined. The two vectors acted as sides of a parallelogram and the resultant was the diagonal. Its length indicated the magnitude of the resultant force on the same scale as the original force. The final movement of the maxillary molar was identical to the resultant.

The two vectors had their point of application in point A – the buccal tube and in point B – the palatal sheath (Figures 3A and 3B): On point A we used a step bend, which created a moment tending to rotate the tooth and also created two couples in the same direction regardless of the step bend location between the brackets. As the line of action did not pass through the center of resistance, tipping of the maxillary second molar was expected. We applied 45 gm force on the tube 6 mm from the center of resistance and produced 270 gm-mm moment (Mf – moment of the force), tipping the tooth.

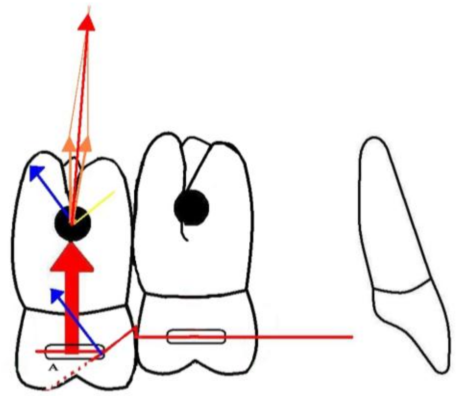

Figure 3 B. Resultant vector (thin red arrow) in combining all forces (orange arrows) at the center of resistance: An intrusive force combined with slight distal and palatal crown tipping is obtained.

To obtain bodily movement we needed to create a moment of the couple (Mc) equal in magnitude and opposite in direction to the original movement. On point B we used a hook at the height of the center of resistance to obtain pure translation. We applied 50 gm force on the tube 6 mm from the center of resistance and produced 300 gm-mm moment (Mf – moment of the force), tipping the tooth very slightly palatally.

This force system was equivalent to a couple with a 30 gm net force to move the tooth bodily (Figure 3 A). Note that during intrusion the height of the hook became more incisal and a couple was being created which moved from infinity to a more incisal position. If this couple was large enough relative to the forces the amount of translation could become negligible in comparison to the tipping and the center of rotation would be near the center of resistance (Figure 3 C).[10]

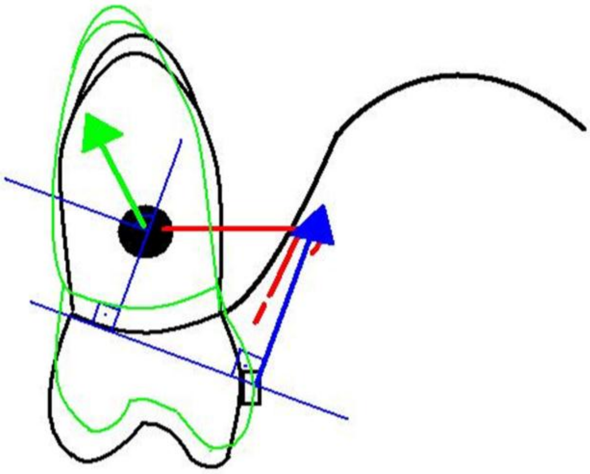

Figure 3 C. Molar cut view and application of the force: The resultant vector (green) indicates a slight palatal crown tipping.

In our model, we obtained an intrusive force of 92.8 gm combined with clinically negligible distal and palatal crown tipping each of less than 15° (Figure 3 B). However, according to the individual environment, each clinical application might produce other unwanted effects.

Figure 4 A1. Pre-treatment intra-oral assessment, buccal view.

Patient A.J.

A 26 year 10-months-old female patient was referred by a general dentist for orthodontic evaluation. Her chief complaint was the missing tooth in the lower right arch. She presented with mild upper and lower anterior crowding, missing mandibular right second molar and extruded maxillary right second molar (Figures 4 A1 and A2).

Figure 4 A2. Pre-treatment study model assessment.

After evaluating the patient's periodontal health condition, the following treatment plan was designed: Full-arch-bonding with edgewise appliances, including the modified semi-palatal bar appliance for intrusion of maxillary right second molar, mandibular right second molar implant placement and retention of the maxillary right second molar in its new position.After the patient's treatment plan approval, the semi-palatal bar appliance was placed (Figure 4 B1) and an Ormco Power Chain (Ormco, Glendora, USA) was tied palatally from the palatal sheath of the maxillary right second molar through the semi-palatal bar helix and back onto the sheath (Figure 4 B2).

Figure 4 B1. Appliance in place (buccal view).

Figure 4 B2. Appliance in place (occlusal view).

After 2 months of intrusive force we obtained space for implant placement of mandibular right second molar (Figures 4 C - F).

Figure 4 C. Lateral view 2 months post orthodontic intrusion.

Figure 4 D. Occlusal view 2 months post orthodontic intrusion.

Cephalometric and panoramic evaluation indicate the successful intrusion (Figures 5 A and B and Figures 6 A and B). The cephalometric superimposition along the palatal plane registered at ANS shows successful intrusion of the second molar (Figure 7 A) and no measurable extrusion of the adjacent molar that was used as anchorage (Figure 7 B).

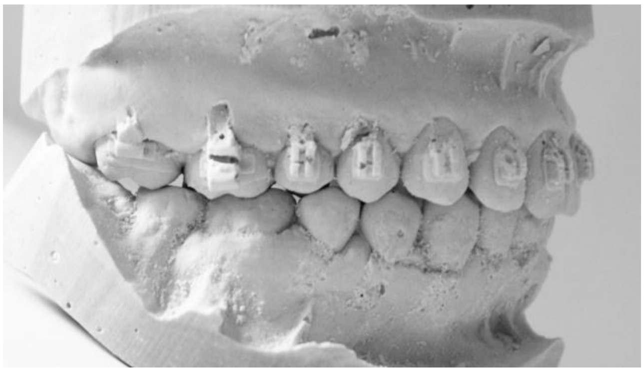

Figure 4 E. Lateral view after implant placement and temporary crown insertion.

Figure 4 F. Lingual view after implant placement and temporary crown insertion.

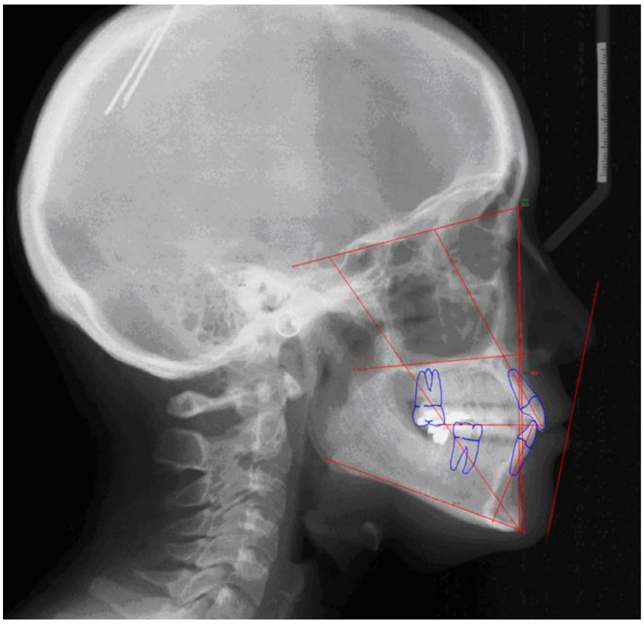

Figure 5 A. Pre-treatment cephalogram.

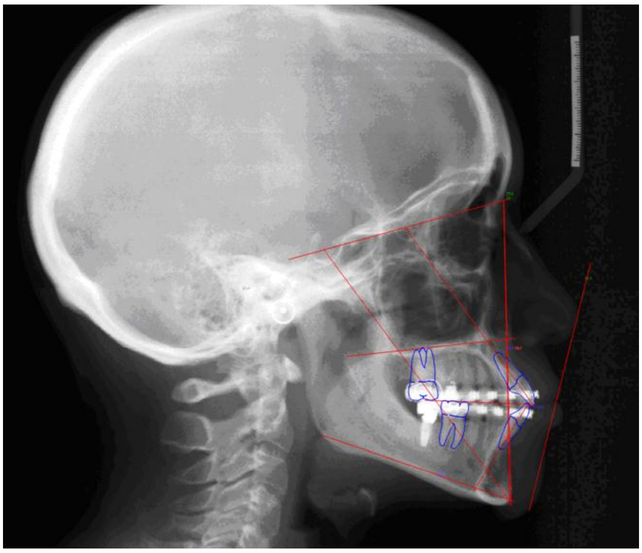

Figure 5 B. Post-treatment cephalogram.

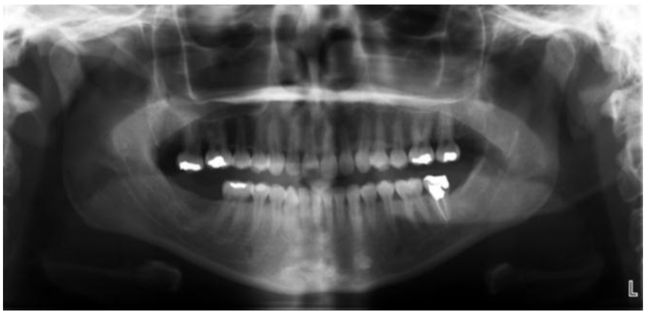

Figure 6 A. Pre-treatment panoramic radiograph of patient 1.

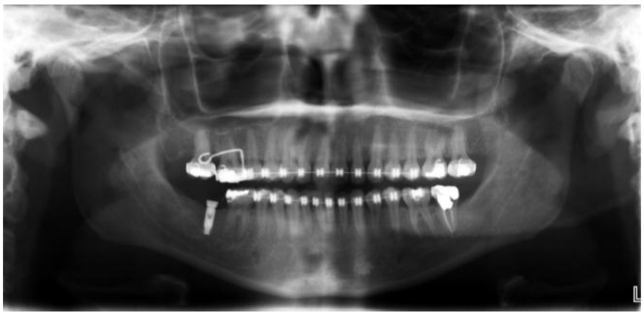

Figure 6 B. Post-treatment panoramic radiograph with implant placement of patient 1.

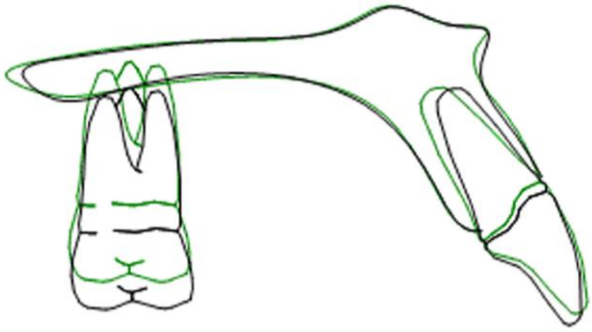

Figure 7 A. Cephalometric superimposition along the palatal plane registered at ANS shows

successful intrusion of upper second molar in patient 1.

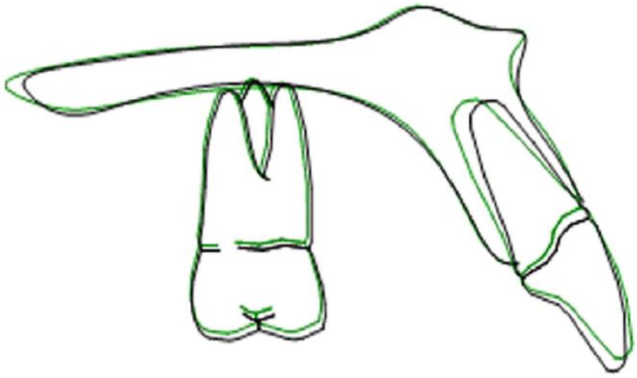

Figure 7 B. Cephalometric superimposition along the palatal plane registered at ANS shows no measurable extrusion of the adjacent upper first molar in patient 1.

Patient D.S.

A 20-year-old female patient presented in 2000 for surgical treatment evaluation of her Cl III malocclusion. After performing orthodontic decompensation, her maxillary right second molar was bucally tipped out of the arch and needed intrusion and correct alignment before performing mandibular setback surgery (Figure 8 A).

Figure 8 A. Pre-treatment occlusal view of decompensated maxillary arch in patient 2.

The semi-palatal bar appliance was placed and a power-chain was tied palatally from the palatal sheath of maxillary right second molar through the semi-palatal bar helix and back onto the sheath. After 2 months of intrusive force the correct alignment was achieved. Clinical (Figures 8 B and C), cephalometric (Figures 9 A and B) and panoramic evaluation indicate the successful intrusion. The cephalometric superimposition shows no measurable extrusion of the adjacent molar used as anchorage. Both maxillary right first and second molar were slightly mesially displaced.

Figure 8 B. Post-treatment occlusal view of clinical successful intrusion of UR7 in patient 2.

Figure 8 C. Palatal view of clinical successful intrusion of UR7 in patient 2.

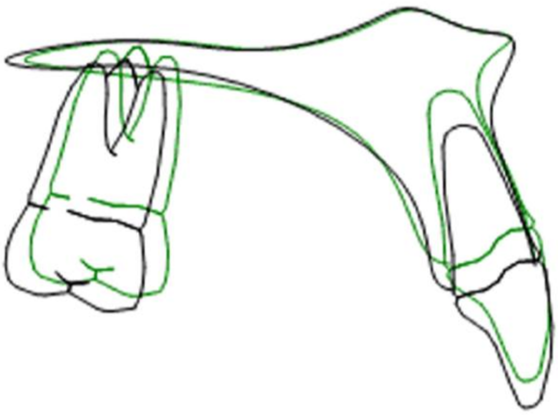

Figure 9 A. Cephalometric superimposition along

the palatal plane registered at ANS shows successful intrusion of upper second molar in patient 2.

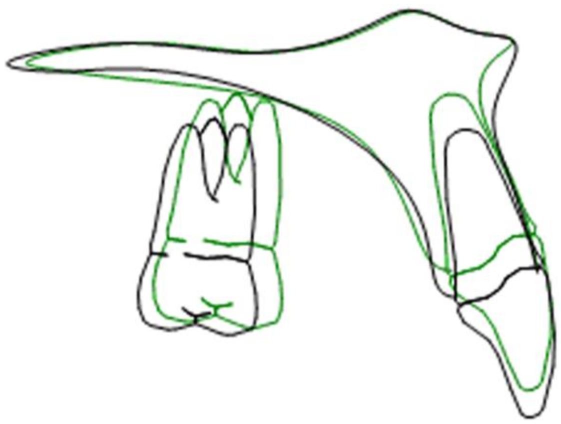

Figure 9 B. Cephalometric superimposition along the palatal plane registered at ANS shows no measurable extrusion of the adjacent upper first molar in patient 2.

Results

Our results confirm that the modified TPA technique is an alternative to conventional methods for selective molar intrusion. In detail, patient A.J. showed an intrusion of 3.5 mm and patient D.S. an intrusion of 1.5 mm over 2 months and 3 appointments.

Discussion

In 2001, Daimaruya examined molar intrusion in dogs through a skeletal anchorage system. Canine mandibular molars intruded by an average of 3.4 mm over the 7 months of observation.[11] The intrusion of about 3.5 mm observed in our patient A.J. is in accordance with previous observations and also with the intrusion observed by Moon and co-workers[12] who achieved first and second molar intrusion in selected patients by the more invasive means of corticotomy and orthodontic skeletal anchorage.

Our proposed method includes full arch bonding to gain a solid anchor during treatment. The previously extruded tooth should be maintained for 6 months in its new position to allow the periodontal ligament fibers to restructure. During treatment, the intrusion surrounding gingival tissue and bony structures were clinically monitored and remained healthy.

Permanent retention needs to be preserved by the restorative substitution of the opposing teeth. Based on cephalometric superimpositions, the expected extrusive force on the adjacent tooth - in this cases the first molar - was not observed in our patients. This may be due to occlusal forces, the stabilizing effect of the buccal guiding archwire, and the use of light force generated by the power chain over an extended period of time. The intrusion of a single tooth concentrates on a small area at the apex. Only extremely light and continuous forces (5 to 15 gm per tooth) should be employed with the line of action of the force directed through or close to the tooth's center of resistance.[13,14]

There is general agreement that forces on posterior teeth should not exceed 100 gm.[15,16] Maintaining a light force application may avoid other unwanted effects of intrusion, e.g. the resorption of the intruding tooth in the apical third. In an animal skeletal anchorage system model, Daimaruya and coworkers found a minimum root resorption of 0.1 mm ± 0.1 mm (mean ± SD) after 7-months of treatment. Root resorption reached the dentin at one-third of the apical area of the roots.[11] Thus, even minimum external apical root resorption can be considered aggressive when localized at the apical region. We could not detect root resorption in our patients; however a much larger number of patients will be needed to exclude unwanted effects generated by this appliance.

Auxiliary anchorage has been used to control the intrusive force, e.g. a base arch (rectangular stainless steel archwire), which includes all teeth except the extruded tooth, together with a buccal intrusion arch. The intrusion arch is segmentally attached to the base appliances. To achieve pure molar intrusion it is necessary to position the point of application of the force more anteriorly (Figure 10).[14]

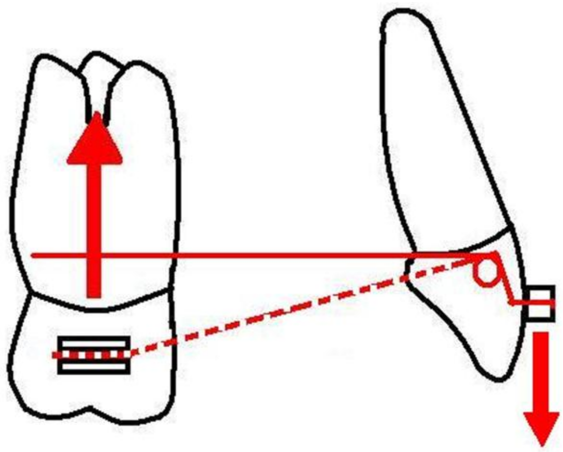

Figure 10. Example of an intrusion arch: this

arch is not inserted into the posterior brackets and unwanted effects are a large tip back moment and a small extrusive force at the incisors.

The extrusive force on incisors can be counteracted by an anterior bite plate, by occlusal forces and / or by an anterior vertical pull (J-hook) headgear.[17] Intrusion of teeth adjacent to the molar may occur as unwanted effect, when those teeth are not connected to the appliances.[18]

Orthodontic intrusion of posterior teeth is difficult to achieve in adults due to missing growth compensation, histological changes in the alveolar bone, smaller marrow spaces and a reduced blood supply when compared with growing patients.[19] To improve anchorage, a combination of corticotomy, miniplates and orthodontic miniscrews has been proposed.[5]

Corticotomy was performed by incising the cortical bone surrounding the tooth to reduce resistance during intrusion. The method is expensive, rarely covered by dental plans and associated with pain, swelling and infection. By combining corticotomy with rare earth magnets, Hwang and Lee achieved an intrusion of 3.5 mm during 2 months of treatment without observing adverse events such as discomfort, root resorption and/or extrusion of the adjacent teeth.[20]

Temporary anchorage devices (TAD) are preferable because they provide maximum anchorage control and minimize the need for full arch appliances. The success rate of more than 75% has been considered favorable.[21] Putative adverse events of TAD's include pain, infection, trauma of anatomical and vascular structures, fracture, dislodgement and gingival overgrowth.[22,23]

Use of 2 TADs to successfully correct an overerupted upper first molar was described by Kravitz and coworkers.[24] In another study using TADs, overerupted maxillary first molars were intruded by 3 to 8mm over 7.5 months (about 0.5-1.0 mm per month), without loss of tooth vitality, adverse periodontal response or radiographically evident root resorption [25,26]

In order to reduce the risk of extruding the adjacent posterior tooth, we employed a modification of previous appliances, such as the Kucher and Weiland's appliance that used similar biomechanics in combination with a TPA to reduce the prominence of the palatal cusp of the upper second molar.[27] In contrast to this appliance we could eliminate the laboratory step.

Gianelly had employed a removable appliance, which anchored on the remaining dentition, pulling from the buccal and the palatal side. He concluded that this type of anchorage was inadequate for restoring an occlusal plane when the overerupted tooth is a terminal tooth. Due to the fact that the occlusal plane is restored by a combination of extrusion / intrusion and extrusion was an easier and quicker movement to be produced orthodontically, Gianelly preferred surgery instead of restoring the occlusal plane.[18] The use of removable appliances instead of fixed appliances may be the cause of the discrepancy between the results of our study and previous studies.

Some intrusive forces on the adjacent molar have also been observed by Gianelly[18], and could be justified by the presence of the horizontal periodontal fibers attached apically to the crown. However, this phenomenon is only noticeable when the adjacent molar is not the direct source of anchorage, in which case extrusive forces will prevail. In our study, the first molar was the direct source of anchorage, and was stabilized by a separate archwire system encompassing the whole maxillary arch. Intrusion was not observed on the maxillary first molars, and extrusion was not observed either.

Another reaction to the intrusion force is that the periodontal pocket might deepen. Caution must be given to the presence of periodontal diseases as these may aggravate and lead to periodontal damage.[13,14] In case of normal intrusion the periodontal fibers are expected to build a junctional epithelium at best, but there is no basis for expecting true re-attachment of the periodontal fibers in response to orthodontic treatment. Melsen et al. described the formation of a tight epithelial cuff in histological slides of a dog's lower first premolar that was first extruded and then intruded.[28]

With our patients, the position of the gingiva relative to the crown was left unchanged while periodontal probing depths did not increase.

Conclusions

Extruded upper second molars are often encountered in adult patients. The modified TPA appliance presents a clinically elegant, non-invasive and cost-effective procedure.

The TPA is rapidly bent in the office and is cost-effective because it does not require laboratory work. This appliance can be inserted in one session chair-side.

Declaration of Interest

The authors report no conflict of interest and the article is not funded or supported by any research grant.

References

1. Lyka I, Carlsson GE, Wedel A, Kiliaridis S. Dentists' perception of risks for molars without antagonists. A questionnaire study of dentists in Sweden. Swed Dent J 2001;25(2):67-73.
2. Christou P and Kiliaridis S. Three-dimensional changes in the position of unopposed molars in adults. Eur J Orthod 2007;29(6):543-9.
3. Thurow RC. Tissue adaptation to functional and orthodontic stresses: Edgewise Orthodontics. 4th ed. St Louis, Mo: CV Mosby Co; 2001:91-106.
4. Sano Y, Ikawa M, Sugawara J, Horiuchi H, Mitani H. The effect of continuous intrusive force on human pulpal blood flow. Eur J Orthod 2002;24(2):159-66.
5. Kohno T, Matsumoto Y, Kanno Z, Warita H and K. Experimental tooth movement under light orthodontic forces: rates of tooth movement and changes of the periodontium. J Orthod 2002;29(2):129-136.
6. Tanne K, Koenig HA, Burstone CJ. Moment to force ratios and the center of rotation. Am J Orthod Dentofacial Orthop 1988;94(5):426-31.
7. Smith RJ, Burstone CJ. Mechanics of tooth movement. Am J Orthod 1984;85(4)294-307.
8. Nanda R. Principles of biomechanics. In: Biomechanics in Clinical Orthodontics. ed. R Nanda, Philadelphia: WB Saunders Co; 1996:3-7.
9. Natali AN. Appliance configuration. Dental Biomechanics, 1st ed. CRC; 2003:202-205.
10. Smith RJ, Burstone CJ. Mechanics of tooth movement. Am J Orthod 1984;85:294-307.
11. Daimaruya T, Nagasaka H, Umemori M, Sugawara J, Mitani H. The influences of molar intrusion on the inferior alveolar neurovascular bundle and root using the skeletal anchorage system in dogs. Angle Orthod 2001;71(1)60-70.
12. Moon CH, Wee JU, Lee HS. Intrusion of overerupted molars by corticotomy and orthodontic skeletal anchorage. Angle Orthod 2007;77(6):1119-25.
13. Melsen B, Agerbaek B, Markenstam G. Intrusion of incisors in adult patients with marginal bone loss. Am J Orthod 1989;96:232-241.
14. Proffit WR, Fields HW. Biomechanics and Mechanics. In: Contemporary Orthodontics. 3rd ed. Missouri: MOSBY; 2000:668.
15. Thurow RC. Tissue adaptation to functional and orthodontic stresses: Edgewise Orthodontics. 4th ed. St Louis, Mo: CV Mosby Co; 2001;91-106.
16. Smith RJ, Burstone CJ. Mechanics of tooth movement. Am J Orthod 1984;85(4):294-307.
17. Natali AN. Appliance configuration. Dental Biomechanics, 1st ed. CRC; 2003:202-205.
18. Gianelly A. Adult Orthodontics. Bidimensional technique. Theory and Practice. Central Islip, NY: GAC International; 2000:238.
19. Melsen B. Limitation in adult orthodontics. In: Melsen B, editor. Current controversies in orthodontics. Chicago: Quintessence; 1991:147-80.
20. Hwang HS, Lee KH. Intrusion of overerupted molars by corticotomy and magnets, Am J Orthod Dentofacial Orthop 2001;120(2):209-16.
21. Crismani AG, Bertl MH, Celar AG, Bantleon HP, Burstone CJ. Miniscrews in orthodontic treatment: review and analysis of published clinical trials. Am J Orthod Dentofacial Orthop 2010;137(1):108-13.
22. Papadopoulos MA, Tarawneh F. The use of miniscrew implants for temporary skeletal anchorage in orthodontics: a comprehensive review. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;103(5):6-15.
23. Park HS, Jeong SH, Kwon OW. Factors affecting the clinical success of screw implants used as orthodontic anchorage. Am J Orthod Dentofacial Orthop 2006;130(1):18-25.
24. Kravitz ND, Kusnoto B, Tsay PT, Hohlt WF. Intrusion of overerupted upper first molar using two orthodontic miniscrews. A case report, Angle Orthod 2007;77(5):915-22.
25. Kravitz ND, Kusnoto B, Tsay TP, Hohlt WF. The use of temporary anchorage devices for molar intrusion. J Am Dent Assoc 2007;138(1):56-64.
26. Yao CC, Wu, CB, Wu HY, Kok SH, Chang HF, Chen YJ. Intrusion of the Overerupted Upper Left First and Second Molars by Mini-implants with Partial-Fixed Orthodontic Appliances: A Case Report. Angle Orthod 2004;74(4):550-7.
27. Kucher G and Weiland FJ. Goal-oriented positioning of upper second molars using the palatal intrusion technique. Am J Orthod Dentofac Orthop 1996;110:466-8.
28. Melsen B. Tissue reaction following application of extrusive and intrusive forces to teeth in adult monkeys. Am J Orthod 1986;89(6):469-75.