

Current Status of Skeletal Anchorage Dental Applications in Orthodontics, Part I

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Orthodontic tooth movement involves application of forces and moments on the dentition. Every force applied on a tooth or group of teeth will generate reactive forces on adjacent structures. Some reactive forces will produce secondary effects that must be controlled. Historically, these reactive forces were dissipated by different strategies. One strategy uses a group of teeth as anchorage in order to move a smaller group of teeth or a single tooth, which can be done within the same dental arch or between upper and lower dental arches. A second strategy would dissipate these unwanted reactive forces against structures external to the dental arches. These include the use of appliances that anchor teeth against the palatal mucosa (Nance button), against the lip pressure (lip-bumper), and against craniofacial structures (headgear).

For the last 15 years, skeletal anchorage (SA), a new modality of controlling unwanted reactive forces, has developed rapidly. SA can be defined as the temporary implantation of a device that prevents unwanted movements of a group of teeth while producing the desired tooth movement of other teeth. SA in orthodontics consists mainly of two types of devices: mini-implants¹⁻³ (also called miniscrews, temporary anchorage devices, microscrews, or minipins) and miniplates (also called Bollards).⁴⁻⁸ The main differences between them are depicted in Table 1.

The purpose of this two-part article is to summarize the current applications of SA in orthodontics to

produce dental movement in three planes of space and to illustrate these concepts with two clinical examples.

THREE-DIMENSIONAL INDICATIONS FOR SA

In the same way that orthodontic tooth movement can be produced in three planes of space, SA can be used to optimize every direction of tooth movement. Applications of SA are shown in Table 2 and will be described in detail for each plane of space.

ANTEROPosterior PLANE: RETRACTION OF TEETH

Perhaps the most frequent use of SA is in the retraction of teeth into an extraction space while maintaining the posterior teeth in their original location.^{9,10} This also can be applied in nonextraction cases where spacing exists among teeth at the beginning of treatment. SA-assisted retraction of anterior teeth can be accomplished with minimal changes at the posterior teeth. Retraction rates for anterior teeth using SA are similar to the retraction rates without SA. Treatment time is increased, given that the entire space is closed by retraction of anterior teeth as opposed to reciprocal closure without SA.¹¹⁻¹⁴

Retraction or distalization of the entire dental arch is also possible by means of miniplates that are fixed to

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TABLE 1. Differences between mini-implant and miniplate

	Mini-implant	Miniplate
Position	Between roots	Above roots
Flap surgery	Not required	Required
Stability	Small forces	Medium forces
Indications	3D tooth movement	3D tooth movement, full dental arch movement, and dentofacial orthopedics

TABLE 2. Based on the current evidence, we have summarized the possible indications for skeletal anchorage for dental movement. Three criteria were followed: feasibility, rationale, and stability

		Possible	Reasonable	Stable
Vertical	Intrusion	**	***	?
	Extrusion	?	???	?
Anteroposterior	Retraction	***	**	**
	Protraction	**	***	***
Transverse	Transverse	**	??	???
	Midline	**	**	**

*represents available evidence.
?represents need for further research.

the jaw in a position above the roots (maxilla),¹⁵ by temporary anchorage devices placed in the palate,^{16–20} by any type of SA positioned distally to the mandibular teeth,⁷ by tipping movement of the dentition and temporary anchorage devices placed between roots²¹ (this approach allows for only limited distal tipping of teeth and not true distalization), or by multiple stages and repositioning of miniscrews between roots after distalization of some teeth has been achieved.

CLINICAL EXAMPLE I: RETRACTION OF INCISORS

Diagnosis and Treatment Planning

Patient presented to the orthodontic clinic with chief complaints of spacing and uneven appearance of her

smile (Figure 1). She was referred to a periodontist for diagnosis, treatment, and maintenance of her moderate generalized periodontitis. After she was cleared as periodontally stable, we initiated our diagnosis and treatment planning. Based on clinical examination and initial records, her prioritized orthodontic problem list included:

- 1 Pathology concerns: patient was diagnosed with moderate generalized periodontitis but deemed periodontally stable. Prognosis for most teeth was fair-to-good; prognosis for LL2 was poor where probing depths were 5 mm. Moderate-to-severe gingival recession was observed at upper and lower incisors
- 2 Alignment/symmetry: spacing of 15 mm in the upper arch and 6 mm in the lower arch was measured. Dental midlines were not coincident, with the upper dental midline positioned 1 mm right of lower dental midline. There was an interarch tooth-size discrepancy with lower incisors 2 mm wider than upper incisors (Figure 2A and B)
- 3 Anteroposterior: skeletal Class I with retrogenia combined with dentoalveolar protrusion and excessive inclination upper and lower incisors were observed. She displayed excessive lip projection and lip strain at rest. The upper incisors were positioned ahead of anterior nasal spine with the head oriented in natural head position. Lower incisors were positioned ahead of pogonion (Figures 3 and 4)
- 4 Vertical: patient had a short lower facial height with decreased mandibular plane angle. Overbite was within normal limits because of excessive proclination incisors. Occlusal surfaces of the upper and lower dental arches displayed wear that indicated some component of overclosure
- 5 Transverse: asymmetric spacing was present in both dental arches. Dental midlines were not coincident with the midsagittal plane. The upper dental midline was observed to be 1 mm right of lower dental midline, and LL2 was in cross-bite with UL2
- 6 Soft tissue/esthetics: as a result of her skeletal malocclusion, excessive lip projection and lip strain at rest were noted. Incisor exposure at smile was adequate



FIGURE 1. Initial extraoral photos. Note the proclination of upper and lower incisors. Patient's chief complaints were the position of the upper incisors and generalized spacing.



FIGURE 2. Initial intraoral photos. A, Calculus and plaque can be observed. Anterior teeth are severely proclined. Spacing is present among incisors. B, Spacing and severe wear on posterior teeth can be observed.

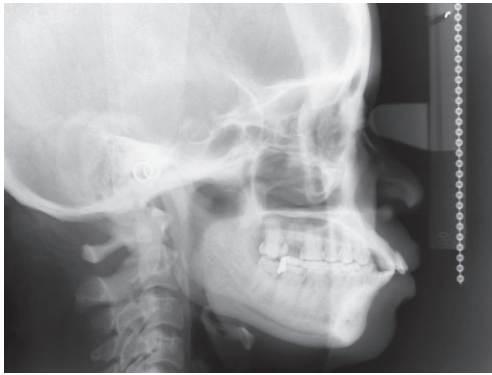


FIGURE 3. Cephalometric radiograph. Note the position of the incisors and alveolar bone. Patient had to strain upper and lower lips to obtain lip closure.

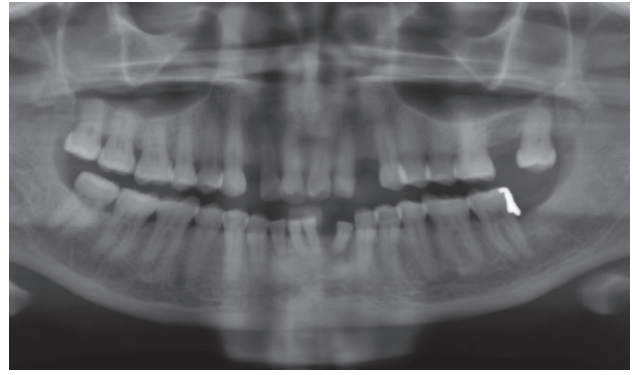


FIGURE 4. Panoramic radiograph. Lower incisors appear short because of their inclination. Moderate bone loss is present among anterior teeth. Defective (overextended) amalgam restoration is present in lower left second molar.

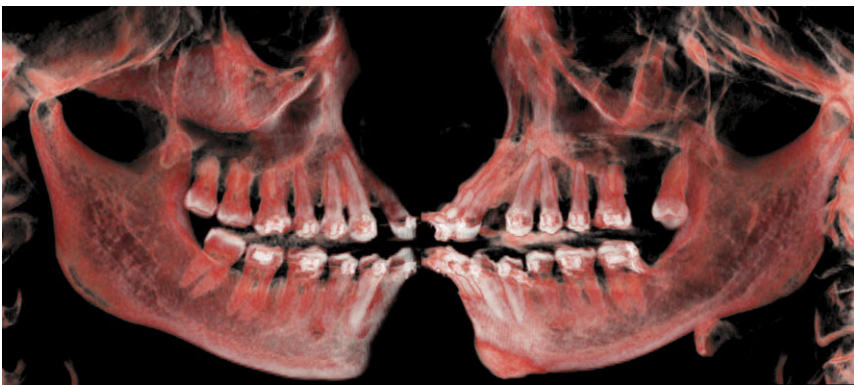


FIGURE 5. Volume rendered from cone-beam computerized tomography (CBCT) images. Both right and left hemicranium are depicted. Note the divergence of roots upper premolars to allow for insertion of mini-implants.

Treatment Objectives

- 1 Space closure by retraction of upper and lower anterior teeth
- 2 Maintenance of anteroposterior dental occlusion
- 3 Slight intrusion of upper anterior teeth to avoid increasing overbite beyond 3 mm and compensating the vertical movement of incisal edge because of the uprightening of incisors
- 4 Minor enameloplasty incisal edge lower incisors to improve root/crown ratio and reduce overbite
- 5 Permanent retention by splinting lower anterior teeth

Treatment Plan

The treatment plan consisted of full upper and lower labial braces with SA to produce retraction of anterior

teeth, closure of spaces, and slight intrusion to counteract deepening of the bite while reducing inclination of the upper incisors. Specific steps included:

- 1 Bond upper and lower dental arches with .022 brackets (MBT Prescription, 3M Unitek, Monrovia, CA, USA)
- 2 Archwire progression: superelastic nickel-titanium to stainless steel round wires
- 3 Diverge roots upper and lower premolars to allow placement of four miniscrews, providing absolute anchorage by holding posterior teeth in position and direct traction of anterior teeth
- 4 Space closure by allowing main arch wire to slide distally, while spaces are being closed with coil springs



FIGURE 6. A, The insertion point is measured and marked on the attached gingiva with a periodontal probe. It was decided to place the mini-implant below the mucogingival line between the roots of premolars (note the bends on the wire to diverge the roots) and at a distance from the labial frenum. A small volume (1/8 of a 1.6-mL carpule of 2% lidocaine with 1:100,000 epinephrine) of local anesthetic is placed to anesthetize only the soft tissue. B, Insertion site is then marked with a soft-tissue punch without cutting into the tissue. Once insertion site is deemed appropriate, the soft-tissue punch is used to create a 1.5-mm diameter access to the alveolar bone. C, After soft-tissue punch, it was decided to drill at low speed a mini-implant site, 4 mm in length and 1.2 mm in diameter. Note that the mini-implant is 1.7 mm in diameter and 8 mm in length. The drilling process is not always necessary; in this case, it was performed to establish a definite direction of insertion and to reduce the pressure and temperature at the cortical plate during insertion. (Note that contralateral side is shown). D, Mini-implant is placed under irrigation until soft-tissue collar compresses the attached gingiva, and hemostasis is achieved. The amount of bleeding in this case was increased because the patient was taking 125 mg of aspirin daily.

- 5 Interproximal reduction lower incisors: 1.5 mm and enameloplasty (vertical reduction) of incisal edges of the lower incisors
- 6 Finishing and detailing occlusion with edgewise wires
- 7 Establishment of parallel roots premolars after removal of micro-implants

Placement of Microimplants and Treatment Mechanics

Four microimplants were placed, between upper and lower premolars. Upper second premolar roots were distally angulated, and upper first premolar roots were mesially angulated in order to place microimplants with



FIGURE 7. Mechanics consisted of an archwire with posts that is connected to the incisors and being pulled distally with coil springs attached to the mini-implants. The wire is allowed to slide distally into the molar brackets. Sectional wires are connecting the premolars, canines, and mini-implant as the posterior anchorage unit resisting the opposite force (mesial pull of the coils) on the posterior teeth.



FIGURE 8. Final photos on the day of appliance removal. A, All spaces were closed except 0.5 mm distal to upper left lateral incisor. Class I dental occlusion was maintained and overbite was 2 mm. B, A permanent bonded retainer was use to retain the position of the lower incisors and to splint them together.

at least 1 mm of bone mesial and distal to the bone-implant interface. Microimplants were inserted at the attached gingival level, under local anesthesia, after soft-tissue punch removal of gingiva. The facial cortical bone was perforated with a 1.2-mm bur to 4-mm depth. Microimplants (Dentaurum, Ispringen, Germany) were 8 mm in length (Figures 5 and 6A–D).

Two microimplants between the upper premolars were used to maintain the position of the posterior teeth while retracting and intruding the upper anterior teeth. The main archwire was free to slide distally into the upper molar brackets. The position of the microimplants in the maxilla allowed for an upward and distal direction of force. Two microimplants

between lower premolars were used to stabilize posterior teeth position while retracting lower incisors. Interproximal reduction of 1.5 mm was applied to lower anterior teeth to resolve inter-arch tooth-size discrepancy and allow for correct inclination that would permit establishing Class I canine.²² During treatment, the patient was under periodontal maintenance every 3 months (Figure 7).

Treatment Outcomes

After 26 months of orthodontic treatment, spaces have been closed (except 0.5-mm space distal to UL2 and 0.25 mm distal to UR2). The upper incisors have been retracted and slightly intruded. Posterior teeth and



FIGURE 9. Extraoral photos on the day of appliance removal. Note the difference in inclination of the upper incisors and improvement of smile appearance.

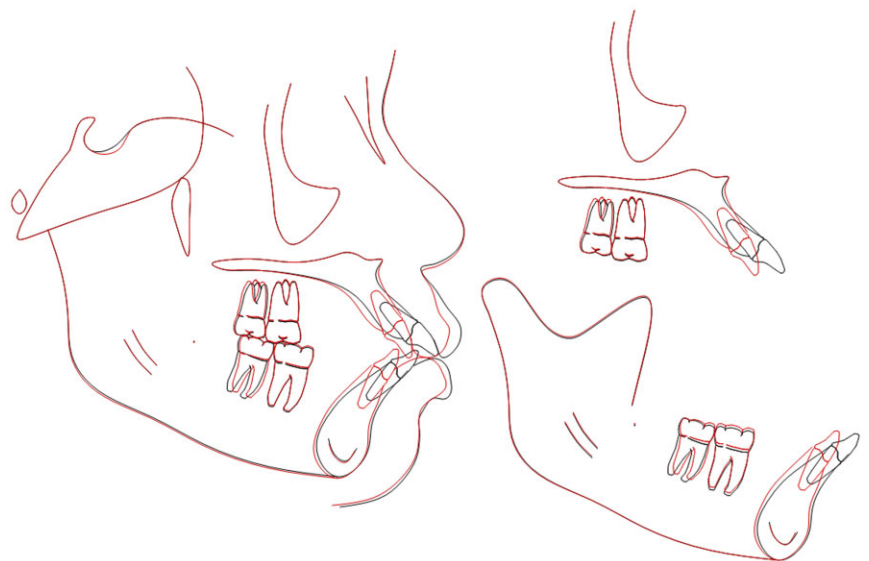


FIGURE 10. Superimposition of pretreatment and post-treatment cephalometric tracings. Note the change in incisor inclination and lip protrusion. Black line represents pre-treatment and red line represents post-treatment.

occlusion were maintained (Figure 8A and B) and the patient was very happy with her smile appearance. Lips position and projection were improved (Figures 9 and 10). Retention included upper bonded retainer attached to each incisor and lower bonded retainer attached to anterior teeth.²³

The patient was given an upper acrylic removable splint to cover the occlusal surfaces for night wear. Six months after debonding, the upper retainer has broken, and it was decided to replace it with a circumferential-type removable retainer, which would allow closure of remaining spaces. A year after



FIGURE 11. One-year follow-up appointment. A, Occlusion was stable, and patient has improved her oral hygiene and self-esteem. B, Changes in incisor inclination are stable if occlusion and lip position improve. Patient also changed her hairstyle.

debonding and after 6 months wearing the circumferential upper retainer, spaces were completely closed. The patient was instructed to wear retainer at nighttime only. She was periodontally stable 1 year after treatment (Figure 11A and B).

CONCLUSION

In some cases, the desired dental movement involves a distal translation of anterior teeth without any mesial movement of posterior teeth. Examples include premolar extraction cases where molars are in good occlusion, and the space is needed to relieve crowding, periodontally compromised cases where bone loss caused a mesial tipping and migration teeth, camouflage of dental Class II with extraction of upper premolars and full Class II molar, and nonsurgical distalization of upper dental arch when patient refuse orthognatic surgery or extraction in combination with orthodontic treatment.

Dissipation of unwanted forces against bone by using SA allows for increased accuracy in treatment

mechanics. These devices expand the amount of dental movement that can be achieved with orthodontic treatment and offer new solutions for the correction of complex malocclusions.

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Contemporary Issues

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