The surgical-orthodontic approach is the most commonly used modality in patients with impacted teeth. It is also the most challenging. The prognosis of treatment is uncertain, treatment takes much longer and is more painful, and the enhanced biomechanical efforts required to bring the tooth to its ideal position frequently cause deleterious side effects to the remainder of the dentition. Skeletal anchorage is a useful aid in these cases. It can be judiciously exploited to assess the prognosis of canine movement, open adequate space for the canine, and build up a reliable anchorage unit that will allow the application of controlled directional forces with fewer side effects on the anchorage teeth. Treatment is facilitated and shortened because the resolution of the impaction may be performed separately before or even simultaneously with treatment of the remainder of the dentition, as 2 distinct force systems. The present article reviews some of the main indications for implant anchorage in treatment of impacted teeth. (Semin Orthod 2010;16:234-241.) © 2010 Elsevier Inc. All rights reserved.

The ability to predict the prognosis of a proposed treatment plan and the length of time needed to achieve it are arguably 2 of the most important factors that face the orthodontist in clinical practice.

The Prognosis of Treatment for Impacted Teeth Is Uncertain

In routine orthodontic treatment, an extremely high proportion of the patients turning to practitioners for correction of misalignments and malocclusion of the erupted dentition may be assured, with confidence, of a good outcome. However, when an impacted tooth is present, many new factors are introduced into the equation that are not usually part of routine orthodontics and that may complicate the course of treatment, seriously undermining the clinician’s confidence of an optimal outcome. Presentation of the treatment plan to the patient in these situations will often include a verbal or written clause preparing the patient for the possibility of failure.

Because the tooth is not visible, accurate positional diagnosis is often difficult, and mistakes may be made even by experts. A tooth in an intractable position may be thought to have a good prognosis, and an inappropriate course of treatment may be prescribed or, alternatively, traction may be applied in an inappropriate direction and the tooth may then be incorrectly misdiagnosed as ankylosed. Underestimation of the anchorage needs may lead to inappropriate biomechanical planning. Inadequate use of imaging techniques may lead to a missed diagnosis of resorption of the adjacent roots. Moreover,
successful outcomes of treatment may founder in the long term because of a poor periodontal condition or inadequate torque. A recent study that analyzed a sample of patients who had been referred for a second opinion and/or retreatment after failure of orthodontic treatment for impacted maxillary canines revealed that the practitioner had most commonly ascribed the problem to ankylosis. However, a critical reevaluation of the reasons for failure showed that the main reasons were poor biomechanical planning of anchorage and an incorrect diagnosis of location and resorption. Ankylosis was only the third factor for failure. In this particular sample of failed cases, the extremely high incidence of ankylosis could have been caused by iatrogenic factors, such as trauma, radical surgery, instrumentation or etchant spillage on exposed root surfaces, or excessive orthodontic forces.

Increased incidence of ankylosis has also been reported with advancing age. In particular, mechanical eruption of palatal canines in patients older than 30 years of age had only a 41% success rate, with most of the failures being found in patients older than 40 years of age.

**Duration of Treatment of Patients With Impacted Teeth Is Longer**

As an important part of their decision process, a patient needs to know how long orthodontic treatment will take before treatment begins. Treatment not completed “on time” is a possible source of friction between the patient and the orthodontist, which may become an additional factor leading to treatment failure. Timely completion of treatment allows more accurate prediction of the number of treatment visits and therefore of costs.

Treatment of a malocclusion in which there is an impacted canine will take longer and will be more painful than treatment of a similar malocclusion, in which all the teeth are erupted. The reason for this is that the biomechanics involved in the resolution of an impacted tooth are difficult to combine with the more routine types of movement obtaining in the overall malocclusion and the 2 cannot usually be performed concurrently. In addition, a surgical exposure procedure is necessary at some point, resulting in some considerable discomfort to the patient.

The average treatment duration for a case with impacted canines is at least 2 years for the unilateral-impacted group and almost 3 years for the bilateral-impacted canine group. Baccetti et al. found slightly lower values for treatment duration (average, 22.1 months); however, their sample included only those “easier” canines in which direct traction of the impacted tooth towards the center of the ridge was possible.

A number of studies have examined the influence of different factors on treatment duration. As mentioned above, the risk of failures increases with age but, even in the successful cases, the length of orthodontic treatment in adults is significantly increased. The reason for the prolonged overall treatment was an increased number of visits required for the canine resolution in the adults in comparison with the young patients. Stewart et al. found that younger patients within their sample had more severely impacted canines, requiring longer orthodontic treatment. However, the older patients in the sample were all younger than 20 years of age, which may not qualify them for comparison as an adult group.

Other factors implicated in increased treatment duration are the height of the impacted canine relative to the occlusal plane and its mesiodistal location and inclination. Alignment of canines positioned higher relative to the occlusal plane, or more mesially relative to their normal place in the arch will take longer to resolve.

A factor that significantly influences the duration of treatment but is frequently ignored relates to the additional period needed to correct deleterious effects created by canine eruption on the adjacent teeth, ie, loss of anchorage. The eruption of an impacted canine is very taxing on dental anchorage and may cause deterioration in the positions of the anchor teeth. Thus, in a fully banded case, the reactive forces incurred in erupting a palatally located canine cause intrusion and flaring of the anterior teeth. The labially directed traction of the canine towards its place in the dental arch creates lingually directed forces on the adjacent teeth and may generate a buccal crossbite on the opposite side of the arch, expressed as asymmetric skew-
ing of the dental arch. The anchor teeth must then be realigned, thus increasing the treatment time. Accordingly, before the attention of the clinician is directed to the resolution of the impacted tooth, a composite anchor unit must be created, involving all the available erupted teeth in the same jaw and, often, in the opposite jaw also. This is usually done by the use of as large a base arch as will fill the slots of the brackets on all the other teeth, with or without the use of intermaxillary elastics. Long periods of orthodontic treatment may lead to damage to the enamel and the appearance of white spots, decalcified areas or even caries if good oral hygiene is not maintained and to more severe root resorption.

Ordinarily, minor mishaps in appliance management will often cause treatment to take even longer. In our recent article on the sample of cases in which treatment initially failed, the mean duration of the first treatment from its initiation to the realization of failure, was 26.2 ± 17.2 months, and the mean duration of the new treatment in the successful cases was 14.4 ± 7.2, meaning that these patients had been treated for 41 months on average in the ultimately successful cases. The range for treatment duration varied between 8 and 82 months, ie, there were patients who were in treatment for almost 7 years until success or, more sorrowfully, admission of failure was declared.

Skeletal Anchorage as a Useful Aid in Treatment of Impacted Teeth

In general there are 2 types of skeletal anchorage systems used in orthodontics, osseointegrated dental implants, including temporary midpalatal implants, and nonosseointegrated mini-plates and mini-screw anchorage systems. Titanium miniplates have been successful in animal trials. In humans, although a few were lost because of infection, the success rate was still very high (between 91% and 100%). A recent study reported that miniplates and palatal implants together showed a 1.92-fold lower clinical failure rate than miniscrews. The main disadvantage of miniplates and palatal implants is the need for more extensive surgery, which has to be done twice (once for insertion and once for removal). However, their advantage is that they are positioned far away from the roots of teeth, thereby reducing the likelihood of dental damage.

Mini/micro-screws have many advantages. They are inexpensive, small, simple to place, immediately loadable, and well tolerated by patients. Their main disadvantage is their proximity to the roots, which may be damaged during placement or when adjacent teeth are displaced. Few long-term studies on nonosseointegrated mini-screws have been published but, in animal studies, success rates have ranged from 90% to 100%. A success rate of more than 75% in human studies is considered favorable for these orthodontic implants, which confirms the clinical applicability of this type of immediate loading anchor support in orthodontics.

Because of the doubtful prognosis of the movement of an impacted tooth in certain circumstances, the high anchorage demands in these cases, and the extended treatment duration, it is surprising how rarely we see published reports on the use of skeletal anchorage in the treatment of impacted teeth. A review of the different possibilities to exploit an absolute anchorage system was written by us a few years ago.

Skeletal anchorage, which is absolute and not relative anchorage, may be judiciously exploited in each of the different stages of treatment:

1. To assess the prognosis of canine movement. There is definite merit in testing the canine before placing orthodontic appliances for both patient and orthodontist, especially in cases in which a favorable outcome is in doubt because of age, cases which had previously failed and cases in which the canines are located in extremely difficult positions, such as transpositions.

2. To open adequate space for the canine. A deciduous canine is narrower than a permanent canine by at least 2 mm. Therefore, despite its presence in the dental arch, there is usually a lack of space for the permanent canine. Skeletal anchorage may be used to distalize the posterior teeth and open adequate space for the permanent canine.

3. To facilitate and shorten treatment. Skeletal anchorage simplifies the approach to the impacted tooth because forces may be applied solely to the affected tooth, thereby avoiding...
the need for a cumbersome orthodontic system. An independent implant system for traction of the canine may be designed and used before or simultaneous with the placement of regular orthodontic appliances which are aimed at correcting the overall malocclusion. By doing this, the period the patient has to wear unaesthetic fixed orthodontic appliances is decreased and will reduce the time that the teeth are exposed to possible deleterious side effects.

4. To reverse anchorage loss. Implants may be employed to close an open bite or reverse an increased overjet caused when traction has been applied to an undiagnosed ankylosed tooth.

**Case Report 1—Use of Direct Skeletal Anchorage to Assess Prognosis**

A 14-year-old patient was referred after previous failure of treatment of a labially impacted canine. According to the first practitioner, the impacted canine initially responded to the eruptive forces but subsequently ceased to move. Loss of anchorage was expressed by intrusion and flaring of the upper anterior teeth, lateral open bite and an increased overjet (Fig 1A). Before deciding on the retreatment plan, it was imperative to know whether the canine was ankylosed. A miniscrew (MIS, Implants Technologies, Ltd, Tel Aviv, Israel) was placed in the labial alveolar bone mesial to the first molar and a distally directed force was applied to the canine (Fig 1B). Lack of movement of the canine confirmed ankylosis. On this basis, retreatment was modified to include extraction of the right upper canine and the left upper premolar. A distinct bony bridge connecting the canine’s labial aspect to the overlying alveolar bone was observed at the time of its removal (Fig 1C).

**Case Report 2—Use of Indirect Skeletal Anchorage to Assess Prognosis**

A 19-year-old patient was referred for a second opinion after previous orthodontic treatment had failed to resolve the impaction of the upper right canine. The patient initially presented a Class I molar relationship with well aligned...
arches and no need for orthodontic treatment except for the impacted canine. To avoid placing unnecessary appliances, we aimed to first confirm canine movement. At the exposure appointment, the tip of the canine was diagnosed to be palatal to the root of the central incisor while the rest of the crown was labial to the lateral incisor (Fig. 2A). This is an unusual but particularly difficult type of impaction to resolve successfully. A miniscrew (MIS; Implants Technologies, Ltd) was placed between the upper right premolars and a stainless steel wire, inserted through the miniscrew’s hole, was bonded to the second premolar (Fig 2B). Thus, here, the miniscrew served as indirect anchorage. Distally, directed forces were applied to the canine by a spring inserted in the gingival tube of the molar band (Fig 2C). After 4 months of unsuccessful traction, we decided to extract the canine, which had to be split in 3 parts in order for it to be removed (Fig 2D).

Figure 2. Use of indirect skeletal anchorage from an implant to assess prognosis. (A) The surgical exposure of the impacted canine, showing its difficult position between the roots of the lateral and central incisors. (B) The use of a miniscrew to reinforce the anchorage unit. (C) the application of a distally directed force to the canine by a spring inserted in the molar tube. (D) The extracted canine. (Color version of figure is available online.)

Case Report 3—Use of Skeletal Anchorage to Shorten Duration of Appliance Wear

A 22-year-old patient was referred for treatment of a left upper impacted canine. She presented a Class I malocclusion, spaces in both arches and the over-retained deciduous predecessor (Fig 3A). The treatment plan was for the upper arch only because the patient refused treatment in the lower arch. The objectives of the treatment were to treat the impaction, bring the canine into its place in the arch, and to close spaces. In contrast to our routine treatment protocol, treatment started with the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnchor, Dentos, Inc, Seoul, Korea) was inserted next to the deciduous canine at the same appointment as the surgical exposure of the impacted tooth. A micro implant (AbsoAnch
plants Technologies, Ltd) was inserted to increase the range of forces exerted by an elastic chain underneath the artificial esthetic pontic (Fig. 3C). Here, treatment was performed with lingual appliances. Figure 3D shows the result achieved.

Case Report 4—Use of Skeletal Anchorage for Distalization

A 26-year-old patient was referred for treatment of 2 upper palatally-impacted canines. The molars showed a mild Class II tendency (Fig 4A). The ZAS (Zygoma Anchorage System, Bollard zygoma Anchor; Surgi-Tec, Bruges, Belgium) was used to distalize the posterior upper teeth bilaterally (Fig 4B, C). After adequate space opening, the canines were actively erupted in the palate and then moved labially (Fig 4D).

Discussion

Implants may be placed in a wide variety of positions, both within and well outside the dental arch and, as such, may be strategically planned and carefully chosen for optimal direction and range of force application to an impacted tooth. They are invaluable in assessing the prognosis of canine movement before appliance placement. They allow the orthodontist to plan treatment that may have been previously unpredictable or even impossible with traditional mechanics, such as distalization of the posterior teeth in adults. Moreover, when using skeletal instead of dental anchorage, less reactive forces are applied to the adjacent teeth, and the danger of negative deleterious side effects, such as root resorption or uncontrolled movement of anchor teeth is significantly decreased. Treatment of the impaction may be performed separately before or even simultaneously with...
treatment of the remainder of the dentition, as 2 distinct force systems. Consequently, treatment duration is shorter and treatment mechanics simpler. Overall costs involved in using these systems, especially the screws, are relatively low and the additional financial burden to the patient negligible.

References


Figure 4. Use of skeletal anchorage for distalization. (A) Initial models showing the lack of adequate space for the canines and the mild Class II molar tendency. (B) Clinical view at the insertion of the zygomatic plates. (C) Distalization of posterior teeth was achieved by open-coil springs inserted between the lateral incisors and premolars. The zygomatic plates were used as indirect anchorage to counteract the mesially reactive forces. (D) After opening of adequate space, the canines were erupted in the palate and then moved labially. (Color version of figure is available online.)