Ancient mariners used the constellations and their individual component stars as landmarks from which to navigate, often in uncharted waters, as they discovered new horizons during their journeys. The advent of miniscrew anchorage provides a new reference, a kind of Polaris or “North Star,” that allows today’s orthodontist to plot courses of treatment that may have been previously unpredictable or even impossible with traditional mechanics.

In view of the plethora of publications, continuing education courses, and marketing materials available to our specialty on the subject of skeletal anchorage, it would seem that the use of miniscrews has become ubiquitous. The reality is much different. In actuality, very few orthodontists have yet to embrace miniscrew use in daily clinical practice. Those who have set sail into this unfamiliar territory have employed them sparingly, and many have elected to have someone else insert them for their patients. It is the authors’ intended purpose to encourage hesitant practitioners to come aboard and incorporate miniscrews on a more routine basis.

**Anchorage Concepts**

In order to move an object, some type of anchorage or countersupport is required to stabilize a force applied to that object. In his Third Law, Sir Isaac Newton specified that every action has an equal and opposite reaction. If we are discussing support for orthodontic tooth movement, then forces that are applied between or across teeth will act on all of the dental units involved, perhaps resulting in unintended tooth movement of the so-called “anchor” teeth. The extent of this movement and also the counter-movement depends upon the anchorage support derived from the individual teeth. In other words, dental anchorage is based on the number of teeth, the length of their roots, the root surface areas, and the structure of the supporting bone surrounding the teeth.

Anchorage quality in orthodontics can be divided into three categories: minimum anchorage, medium anchorage, and maximum anchorage. These three categories may be easily described with the example of conventional canine retraction after removal of a first premolar (Figure 1). If only the individual teeth involved in the mechanism provide support, you have minimal anchorage. Figure 1A demonstrates that a single premolar will not provide sufficient anchorage to retract the canine; rather, the premolar will likely be moved mesially, and there will be anchorage loss. Figure 1B shows two equal anchorage segments where action and reaction are comparable, and the result is medium anchorage and reciprocal tooth movement. In Figure 1C, the posterior group of teeth is secured and stabilized with a miniscrew (indirect anchorage). The canine can then be retracted without mesial movement of the posterior teeth as the reactive force is completely absorbed by the anchorage block. This is maximum anchorage.

Apart from the quality of the anchorage, the location of the anchorage support is also an important factor. A multitude of different anchorage devices have been employed throughout the first century of our specialty.

Methods of dental or desmodontal support have included the following:

- intraoral, intra-arch devices (such as
the Nance holding arch, transpalatal arch, lingual arch, and lip bumper);
• modification of fixed appliances (buccal root torque to move roots into the cortical plate, blocking groups of teeth together, tip-backs or “setting anchorage,” uprighting springs and auxiliaries); and
• interarch mechanics (Class II or III elastics, fixed functional appliances).

Extraoral support has been provided by headgear and face masks.

The tools of skeletal anchorage support include implants, on-plants, and miniscrews.

This article describes anchorage only within bony structures; therefore, the terms “skeletal” and “cortical” anchorage are used interchangeably.

History and Overview of Skeletal Anchorage
The era of skeletal anchorage began in 1945 when Gainsforth and Higley inserted screws into jawbone. Many experiments were unsuccessful, and the method had become virtually obsolete by the late 1970s. Starting again in 1980, various research groups (such as Creekmore and Eklund, Roberts et al., and Turley et al.) took up the subject once more. Creekmore and Eklund published the first clinically successful patient treatment case in which a metal post served as anchorage to intrude maxillary incisors and reduce an overbite.

There are now numerous options for cortical anchorage, ranging from the use of (artificial or pathologically) ankylosed teeth to miniplates (adapted from orthognathic surgery) and even prosthetic osseointegrated implants (Figure 2). Wehrbein and co-workers were the first to present an implant system specially designed for orthodontics (the Orthosystem from Straumann). Another example, the Midplant (HDC), was designed, like the Orthosystem, to be inserted into the palate. Both methods have been demonstrated to be safe and successful.

In recent years, the requirements for cortical anchorage techniques have been carefully defined in the literature. Under closer inspection, miniscrews appear to have the edge compared to other methods due to numerous advantages:
• biocompatibility;
• small size;
• simplicity of insertion and use;
• favorable primary stability;
• capacity for immediate loading;
• adequate resistance against orthodontic forces;
• ability to enhance typical orthodontic mechanics, often independent from patient cooperation;
• improved treatment effectiveness and efficiency;
• ease of removal; and
• cost-effectiveness.

Miniscrew Properties
All types of skeletal anchorage (including miniscrews) are, by definition, implants. It is important, however, to differentiate miniscrews from typical dental implants.

More than 30 different terms for skeletal temporary anchorage screws are in use in the international literature. The most common of these are mini-implant, mini-pin, miniscrew, or TAD (temporary anchorage device). The term “miniscrew” appears to provide the most accurate (and most palatable) description of these “miniature screws,” especially when discussing their use with prospective patients (Figure 3). There are also more than 30 manufacturers of miniscrew systems (Figure 4, page 40), with the number of different screws offered per system ranging from two to 154. It can be an overwhelming and perplexing process to sort through all of these options and select those
devices that are needed for daily practice. The following is an overview of the most important decision-making criteria for choosing a miniscrew system.

**Materials**

Miniscrews are typically fabricated from pure titanium or from an alloy of titanium with aluminum or vanadium. The safe biocompatibility of these materials when in direct contact with bone has been clearly proven in the literature.

**Osseointegration**

Branemark was the first to define the concept of osseointegration. He described it as “a direct functional and structural link between living bone tissue and the surface of a force-absorbing implant.” Several authors have indicated that there is no intention to anchor miniscrews by osseointegration; rather, primary retention is described as a “skeletal resistance block.” In the opinion of Cope and Bumann and co-workers, miniscrews are specifically anchored by mechanical stabilization and not by osseointegration. Since typical dental analogue implants and miniscrews are fabricated from the same materials, there appears to be nothing to preclude osseointegration, except the lack of surface coating and the smaller surface area of the miniscrew.

**Miniscrew Diameters**

The stability of a miniscrew in the bone depends primarily on its diameter, and not on its length (Figure 5). The diameter of available miniscrews varies between 1.2 mm and 2.3 mm. In this case, “diameter” is the outside diameter of the threads. For safe and secure primary mechanical stabilization, a minimum amount of bone is required around the shank of the miniscrew (Figure 6). Although there is no definitive answer as to the amount of bone required, it appears that from between 0.5 mm to 2 mm is necessary for stabilization to reduce premature loss. The amount of bone between the roots of teeth, therefore, defines the maximum diameter of screw that can be used in a particular site. In short, the total distance between roots should be at least 1 mm greater than the diameter of the chosen miniscrew to provide adequate bone support.

It is preferable to place miniscrews through attached mucosa. Not only is the insertion easier, but there is also less risk of tissue damage and subsequent tissue irritation or overgrowth of the implant. Publications by Poggio et al., Schnelle et al., and Costa et al. provide some clues as to the vertical distance that is typically available between the cementoenamel junction (CEJ) and the mucogingival junction (MGJ). These investigations clearly show that the diameter of an interradicular miniscrew should not exceed 1.6 mm. An exception may be miniscrews inserted into the infratemporal ridge or on the lingual alveolus between the maxillary first molar and the second premolar. This, in fact, is the site with the widest interradicular space (Figure 7, page 42).

**Miniscrew Lengths**

The length of the various miniscrews on the market ranges from 5 mm to 14 mm. Typically, the length of the miniscrew refers only to the shaft or shank (the threaded section). As with the diameter, the selection of the length of a miniscrew is dependent upon the amount of bone available. Depending on the region, the total thickness of the alveolus is between 4 mm and 16 mm. The length of a screw, however, is of secondary importance when it comes to secure anchorage—the diameter is much more critical. Various investigations have shown that the thickness of the cortical plate plays the most important role in miniscrew stability. For example, FEM analyses have demonstrated that the typical orthodontic load is applied only in the region of the cortical bone. When selecting the length of a miniscrew, the depth of the gingiva must also be considered. The average depth of the gingiva is about 1.25 mm except in a few locations such as the retromolar region. The ratio between the length of the head (the part of the miniscrew outside the bone) and the length of the threaded shaft (the part of the screw inside the bone) should be at least 1:1. Consequently, Poggio et al. recommended miniscrews lengths of 6 mm to 8 mm, and Costa suggested that miniscrews...
should be from 6 mm to 10 mm. On the basis of these investigations, it would appear that longer screws are unnecessary except in unusual circumstances. This has also been confirmed by numerous, anecdotal clinical experiences.

Color-coding of miniscrews for different lengths or diameters helps to facilitate the selection process. This color-coding is accomplished by an anodized surface coating (such as that used by Forestadent’s Ortho Easy). This oxide layer also appears to enhance retention of the miniscrew.

Miniscrew Head Design

Some suppliers have a special head variation for every potential orthodontic application including:

- hook tops;
- ball-shaped heads;
- eyelets;
- simple slots;
- cross-shaped slots; and
- universal heads.

The screw head must be very small and compact (low profile) to ensure that the patient experiences minimal discomfort and tissue irritation (Figure 8). On the other hand, the head must also be large enough so that the coupling elements (such as coil springs, wire segments, auxiliaries, and elastic chains) can be easily and securely fastened to it (Figure 9, page 44).

Transgingival Portion

The transgingival portion, also known as the gingival neck, is a most important part of a miniscrew. Perforation of the gingiva occurs when a miniscrew is inserted. This provides a potential access route for microorganisms, thereby posing a risk of perimucositis or peri-implantitis, one of the main causes of premature loss of miniscrews. During the immediate postoperative phase, the mucosa should adapt as closely as possible to the screw to seal the area. The most advantageous shape for that to occur appears to that of a cone, as this shape naturally results in a safe seal without a pressure zone. A cone-shaped transgingival collar appears to seal the mucosal perforation wound, much as a cork seals a bottle, and it may help to reduce bleeding. Some miniscrews feature no transgingival collar so that the screw resembles a pan-head screw. These types of miniscrews may result in a void between the screw and the soft tissue that could provide a site for plaque or debris accumulation.

Simplification of Inventory

It seems readily apparent that choosing a specific miniscrew that could be used for the majority of clinical applications would simplify the process of incorporating them into daily practice. Miniscrews with a head design featuring either some type of cross-slot or tube can be used for both direct and indirect anchorage mechanics. In addition, screws of 1.4 mm to 1.6 mm in diameter provide for adequate strength and sufficient primary stability (dependent upon available bone), and only upon occasion will larger-diameter screws be needed (for placement in the infrabyte ridge or lingual alveolus between the upper first molars and second premolars). Miniscrews 8 mm in lengths are suitable for the majority of applications; however, a few screws of 6 mm and 10 mm length could be kept on hand for specific locations. These guidelines should help you to streamline your selection process and maintain a cost-effective inventory.
Conclusions

Although the application of skeletal anchorage concepts to traditional orthodontic mechanics has opened new vistas of treatment predictability, effectiveness, and efficiency, universal adoption of miniscrews throughout our specialty will endure some growing pains. Although miniscrews are not vital for the majority of patient care, they can certainly improve many aspects of specific treatment mechanics and help to reduce reliance upon patient compliance.

References for this article are available with the online version at OrthodonticProductsOnline.com.
REFERENCES