New perspectives on miniscrews: improving stability

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SUMMARY

With the appearance of bone anchorages, orthodontists thought that they would finally be able to overcome the thorny problem of patients’ cooperation. The first considerations were about the safety, the holding time, and the reliability of these devices. Both theoretical and clinical studies have attempted to answer to these questions, and several studies have been published on the same. What have we learned about the reliability of miniscrews 20 years after their introduction in our daily practice? Are they only a way to solve the problem of patient noncompliance? And finally, in which way are they going to evolve? These are questions we aim to answer in the light of the past and the current literature.

KEYWORDS

Temporary anchorage device, miniscrew, orthodontics

NEW PARAMETERS FOR IMPROVED STABILITY OVER TIME

In 2002, there was considerable variability in screw design. Melsen’s work has paved the way for numerous studies aimed at improving the stability of miniscrews in the short to medium term¹⁴-¹⁶,²⁸. The latest developments are summarized below.

Short-term stability

The stability of the screws, defined as their stability over the entire duration of the active phase of treatment⁴³, is linked to three types of parameters: screw morphology itself, the patients, and finally the practitioners.

The morphology of the screws has been a topic of discussion for approximately 10 years²⁷. The characteristics include the following: the design and length of the threaded part, the diameter of the screw (Fig. 1), the design of the gingival neck, and the shape of the head. These technical characteristics seem to be well defined for transgingival screws implanted in the cortical bone. There are two types of screws: self-drilling and self-tapping. There was no initial difference in grip nor in shape or strength⁴⁵,⁴⁹, be it conical or cylindrical. There is a recommended length of >8 mm at the maxilla and 6 mm at the mandible⁴²; regardless of the...
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Medium-Term Stability

The challenge here is to maximize the screw grip without having attained osseointegration\textsuperscript{13}. Surgical screws made of steel, pure titanium, or titanium alloy–aluminum–vanadium Ti\textsubscript{6}Al\textsubscript{4}V are available on the market.\textsuperscript{1} The surgical steel and the titanium alloy have mechanical properties which decrease the risk of fracturing the screw during its installation or removal. Different surface treatments have been tested and are proposed: microsandblasting, chemical etching, and mechanical machining.

Nevertheless, none of these treatments have proven to be superior in medium-term behavior in comparison with the others\textsuperscript{37}. The type of orthodontic mechanisms used does not influence the stability of the screws, whether it is molar distalization by anchoring in the alveolar or palatal bone, mass recession of the arch, molar intrusion, or correction of incisal overbite by intrusion\textsuperscript{35,37}. Long-term stability is also dependent on the control of inflammation and the sprouting of soft tissue.
around the screw. Keratinized gingival implantation is strongly recommended in the literature. However, implantation in the keratinized zone does not guarantee the absence of inflammation (Fig. 2). The implantation zone is a space bordered by the crestal apex and the mucogingival line. The placement of screws in these areas is hampered by the challenge of root morphology. Avoiding root proximities is crucial to the stability of the screws. To do this, it is possible to vary their insertion angles (Fig. 3). However, it should be noted that if a screw placed in contact with a root, only minimal damage occurs if it is quickly removed and if the cement repair is performed quickly and efficiently.

Today, the stability rate of the screws is >92%. As a result, the use of miniscrews has increased considerably in recent years. For example, a recent study shows that 62% of German orthodontists use bone anchors, >50% of whom use them on more than two new patients per quarter.

ARE THE PATIENTS RELIEVED OF THEIR DUTY TO COOPERATE OR ARE THERE NEW RESPONSIBILITIES?

The use of the miniscrews implies that there is no need to request the patient’s cooperation in terms of wearing extraoral appliances or interarch tractions. However, these bone anchoring devices have in fact
shifted the need for patient cooperation away from the device and toward maintaining hygiene in the area surrounding the screw.

**Problems with cooperation**

The success of orthodontic treatments as well as their duration are dependent on different criteria among which three are the direct responsibility of the patients: poor oral hygiene, improper wearing of the interarch elastic, and the detachment of attachments. Patient cooperation is, therefore, a key issue for us. Most practitioners have encountered difficulties in motivating the most recalcitrant patients. Numerous patient compliance devices, e.g., in the area of upper molar distalization, have been compared. Among these are the traditional pendulum, distal jet, and jig. It seems that none of the devices is devoid of confounding effects (tipping, loss of vertical control, and rotation) or undesirable effects (pushing of the pellets in the palatal mucosa, breakage of the device). The desire to avoid having to constantly solicit our patients’ cooperation has cost us in terms of efficiency.

To this end, it became mandatory to develop new techniques, which were both more efficient and less dependent on patient cooperation. The contributions of bone anchor screws facilitated the implementation of treatments, which were previously deemed complicated given the extent of the cooperation required.

Table I: Comparison of the devices studied or described by Melsen, Wilmes et Chillès.

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<tr>
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<th>B. Melsen</th>
<th>B. Wilmes</th>
<th>D. Chillès</th>
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<tbody>
<tr>
<td>Area of insertion</td>
<td>Keratinized mucosa in the alveolar bone.</td>
<td>Medial or parasutural raphe.</td>
<td>Maxillary: infrrazygomatic, subnasal Mandibular: retromolar trigon, zone Parasymphysial area, alveolar bone at the molar level.</td>
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<tr>
<td>Radiographical</td>
<td><img src="image1.png" alt="Radiographical assessment" /></td>
<td><img src="image2.png" alt="Radiographical assessment" /></td>
<td><img src="image3.png" alt="Radiographical assessment" /></td>
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<td>assessment</td>
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<td>Type of screw</td>
<td>Transgingival, minimum 1.2 mm in diameter and 6 mm in length</td>
<td>Transgingival, 2 mm in diameter, length of 7–15 mm</td>
<td>Subperiosteal microscrew, diameter 2 mm, length 3–4 mm</td>
</tr>
<tr>
<td>Advantages</td>
<td>• Easy to set up</td>
<td>• Easy to set up</td>
<td>• No embedding</td>
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<td></td>
<td>• Can cover the entire arch</td>
<td>• Autonomous system allowing asymmetrical molar movements without multiaxial attachment</td>
<td>• No inflammation around the screws</td>
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<td>Disadvantages</td>
<td>• Root proximity and noble elements</td>
<td>• Unimaxillary device</td>
<td>• Incision needed</td>
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<tr>
<td></td>
<td>• Sprouting and possible burial</td>
<td>• Custom-made connectors</td>
<td>• Custom-made connectors</td>
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<td></td>
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<td>• Cost</td>
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NEW PERSPECTIVES ON MINISCREWS: IMPROVING STABILITY

The bone anchors continue to improve, opening the way to new orthodontic mechanics. From the transgingival screws described by Melsen, which are inserted into the alveolar bone, other devices and insertion sites have been developed (Table I).

This is the case for maxillary tuberosities. Screws ≤12 mm in length are implanted at a distance from the

Figure 4
Insertion of subperiosteal screws. A very thick flap was created, concomitant to which the connection was made in steel. The two screws were inserted into the loops. The flap was replaced and sutured with a 3-0 suture material.

Figure 5
In the case of subperiosteal microscrews, the risk is the embedding of the connector, making it difficult to use and painful for patients. This is directly related to the patients’ lack of hygiene.

from patients. These treatments are both orthodontic\textsuperscript{36} and orthopedic\textsuperscript{19}.

However, unimaxillary bone anchor treatments do not facilitate a potentiating effect on mandibular growth in order to resolve class-II cases. It is, therefore, necessary to produce a detailed diagnosis and to define our objectives according to the extent to which a maxillary recoil and a mandibular advancement are desirable. The maxillary screws thus constitute an alternative, in the strictest sense, to the pendulum, distal jet, and other EOF devices used in the maxillary recoil, but they do not very often promote mandibular growth.

Although it is true that the patients’ cooperation is no longer required because of the use of bone anchor screws, it is still necessary during the installation of the screws, a stage which can be tricky in children, adolescents, or even adults.

In addition, an impeccable hygiene regimen must be maintained by the patients throughout the treatment. If they fail to do this, they risk the manifestation of mucosal inflammation which will affect the smooth functioning of the mechanics and, in the worst case scenario, will compromise the stability of the screw.

New perspectives

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Case of placement of a canine retained vestibular in an 11-year-old patient. A flap is lifted to stick a button on the canine. This is connected by a metallic ligature to the active end of the “CT8-1” connector (Cortical-TMA-8-1-arm termination) fixed in the same session against the cortical bone of the zygomatic process by two embedded microscrews for a 3D control, and which emerges at the bottom of the vestibule at the molar level. (Courtesy of Dr. Daniel Chillès.)
NEW PERSPECTIVES ON MINISCREWS: IMPROVING STABILITY

distal faces of the last molars. They serve as a direct anchorage for a progressive recoil of the maxillary arch.

They offer an alternative to traditional anchor plates. Although they require an incision line, it is easier to insert them. There are multiple areas of implantation. In the maxilla, they are mainly infrazygomatic and subnasal. At the mandibular level, there are the symphyseal regions, partly posterior to the crown and the retromolar trigon. The indications are vast: direct or indirect anchorage, anterior retraction, incisal or molar intrusion, adjustment of the molar axis, and insertion of canines retained among others (Fig. 6).

An implantation in the medial raphe area is also possible because it is anatomically safe. Wilmes has developed a set of connectors that can be supported by two palatine screws 11-mm and 9-mm long by 2-mm wide. The most anterior one is placed on the third palatal papilla, and the second is placed approximately 0.9 mm behind (Fig. 7). The steel connectors allow symmetrical or nonsymmetrical molar distalization and mesialization, with vertical dimension control (Fig. 8).

Other titanium alloy connectors can be used to position the retained canines or simply to intrude a sector. The advantage of these aids is to decrease the length of time spent wearing the multiattachment apparatus compared to other bone anchors, this allows both a better acceptance of the device and proportionally decreases the risk of problems like detachment, leucoma, or even gingivitis. This is only put in place after having established the desired molar ratios or after having engaged the canine on the arch. In addition, lingual or vestibular bonding, or even treatment with aligners, may be performed (Fig. 9).

However, this type of device encounters the same challenges as more conventional transgingival screws, i.e., the embedding of the screws (Fig. 10) or of the connectors (Fig. 9). The

Figure 7
The Beneslider system is based on two screws implanted at the level of the medial raphe or on either side of the palatal suture. Note the proximity of the screws to the nasal cavity.

Figure 8
Wilmes device with its rigid connection allows a recoil intrusion of the molars. Tipping is limited to the play of the tube surrounding the connector. Depending on the divergence of the connection with the occlusal plane, an intrusion or extrusion may be imposed on the molars.
analyze the system they set up and keep in mind that miniscrews do not remove all the confounding effects, as new mechanical constraints are produced.

**CONCLUSION**

Owing to the evolution of miniscrews over the past 20 years, as well as the experience gained by orthodontists, the use of these aids is becoming more and more frequent. However, pushing the limits of treatments in terms of the type and amplitude of movements begs two questions. The first concerns the safety of the treatments and their undesirable effects. For instance, can we assume that a 5-mm molar recoil is feasible and poses no threat of radicular resorption under the pretext that it is assisted by bone anchors? The second question concerns the stability of the complex treatments facilitated by these anchorages. For example, will the closure of an anterior open bite depression of the anterior part of the connector may occur during anterior recoil in class-II treatment.

It is noteworthy that there are other devices that rest on the palatal screws. In the end, they all have a dual purpose: facilitating the orthodontic mechanics by decreasing the need for patient participation but also limiting any undesirable effects. To achieve this, the practitioner must carefully analyze the system they set up and keep in mind that miniscrews do not remove all the confounding effects, as new mechanical constraints are produced.

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Figure 9
*After establishing molar class-I ratios, the maxillary arch is glued. The Beneslider® then constitutes a maximum anchorage on the molars. The multiattachment can be vestibular or lingual. Note the embedding of the device when the incisors are retracted.*

Figure 10
*The central plate of the connector can be covered in case of insufficient hygiene. Disinfection can only be conducted under local anesthesia.*
be stable in the long-term without making any assumptions as to its etiology. The use of anchorage screws must always be well thought out and must under no circumstances be displaced by the rigorous control of the mechanical devices installed.

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**BIBLIOGRAPHY**


