Factors Contributing to the Success or Failure of Skeletal Anchorage Devices

An Informal JCO Survey

Editor's Note: JCO recently polled a number of editors and other prominent orthodontists who have considerable experience working with skeletal anchorage. The question was: "In your experience, what are the most important factors determining success or failure with skeletal anchorage, and why?" Here are their replies.

As chairperson in a graduate program, it is obvious to me that experience is most important for success in the use of skeletal anchorage. Failures are reduced if the doctor refrains from inserting miniscrews where the prognosis is dubious. The quality of bone is the most important factor determining primary stability. According to Dalstra and colleagues,[1] the strain obtained by loading a miniscrew perpendicular to the long axis with 50cN leads to loss of primary stability when the cortex is equal to or smaller than .5mm.

Factors related to the insertion procedure: The insertion angle should be kept stable during insertion, and the threaded part should be inserted totally into bone.

Factors related to the screw: We prefer an asymmetrical pitch and a collar that is larger than the threaded section.

Factors related to loading: Loading perpendicular to the long axis is preferable. If the screw is used indirectly by adding a cantilever to a bracket-like head, a force generating a moment around the long axis should be avoided.

With increasing experience, the failure rate of miniscrews can be reduced to around 5%, basically by improving the handling procedure and avoiding skeletal anchorage in situations where the risk is significant.

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Treatment planning and miniscrew placement are the two factors the orthodontist can control. Treatment planning is critical for several reasons: First, one screw size (length and diameter) doesn't work well for all areas of the mouth. Tissue thickness, cortical bone thickness, interradicular spaces—all of these factors demand that the clinician make wise temporary anchorage device (TAD) size determinations prior to placement. Second, indirect anchorage is typically more stable for a miniscrew than direct anchorage. When I plan treatment, I always attempt to set up my mechanical construct so that I can employ indirect anchorage if possible. Obviously, there are certain mechanics, such as molar intrusion or full-arch movement, that cannot be done with indirect anchorage. Third, plan wisely when placing the screw or screws, so that resultant tooth movement doesn't jeopardize their stability. For example, if correcting a maxillary cant by unilateral intrusion, attempt to place the miniscrew in attached gingiva high enough to provide both mechanical advantage as well as clearance from the screw as the roots of the teeth slowly change their positions. Often clinicians are so focused on the placement of the screw, they don't take time to predict where the final root position will be relative to the miniscrew, and they end up having the TAD fail due to root impingement.

The second factor in determining success is the actual miniscrew placement. I frequently observe doctors placing screws with far too much insertion pressure. Moderate initiatory pressure is required to engage the first several screw threads, but after that, insertion pressure should be backed

off to allow the screw to draw itself in with each rotation. This will prevent stripping and screw-hole widening. The other phenomenon that I have observed over the years of watching doctors place miniscrews is a gradual, almost indiscernible forward movement, away from the practitioner, of the hand and driver shaft with each turn of the screw. Not only does this change the initial trajectory of the miniscrew, thus increasing the chance of root impingement, but more important, it again widens the hole around the miniscrew, ultimately dooming it to failure.

JOHN GRAHAM, DDS, MD
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Miniscrews and miniplates are a useful part of the orthodontic armamentarium. Their use has followed, as with all techniques, a phase of rapid development and enthusiasm; now reality has set in, and we can identify indications for skeletal anchorage in a more precise way.

I limit the use of miniscrews to cases requiring intrusion of the upper posterior segments in adults with skeletal open bite, and when simultaneous mesial movement of both right and left molars is needed. Other fields of application are patients with multiple tooth agenesis and skeletal anchorage for molar-distalizing appliances. My experience with miniplates concentrates on their use in combination with Class III elastics for the orthopedic treatment of Class III, according to Dr. Hugo DeClerck's protocol.

The failure rate of miniscrews or miniplates in my practice is probably more than 10%.

TIZIANO BACCETTI, DDS, PHD
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Success factors:
- Thick cortical bone
- Amplitude of the contact area between cortical bone and miniscrew

Failure factors:
- Thin cortical bone
- Contacting root or periodontal membrane
- Wiggling action during miniscrew insertion

Clinicians must acknowledge that there are some unpredictable factors involved in the stability of mini-implant anchorage.

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Just like any other technique, micro-implant (MI) placement has a learning curve. The published rates of success are generally above 90%; in the real world, a clinician may experience a 75-80% success rate, depending on the level of skill. It is important that clinicians understand all the factors related to stability of MIs before placing them.

Host factors: Good quality and sufficient quantity of bone are important to ensure the initial stability of an MI. Enough interradicular distance should be available to minimize the risk of root contact, which has been shown to cause higher failure rates. Park and Cho have published a summary of MI insertion locations[2]: in alveolar bone, the best sites are between the first molars and second premolars, where sufficient interradicular space is available; midpalatal and retromolar pad areas have sufficient cortical bone thickness and provide excellent sites for MI. Adequacy of interradicular space should always be ascertained with at least a pano; even better is measuring the actual space available with cone-beam computed tomography. If possible, it is best to place MIs in the attached gingiva to lessen the chance of inflammation, a factor associated with higher MI failure rate. In biomechanical situations that require placement in the loose mucosa, a careful insertion technique (by stretching the mucosa during insertion) and careful hygiene instruction should help achieve satisfactory stability.

Operator factors: A self-drilling and self-tapping technique is preferred, using only topical anesthetic and watching for patient discomfort, which indicates possible root contact. A continuous, nonwobbling force helps keep the MI in a straight path.

We have the patient or assistant brace the opposite side of the patient's mandible and the face to prevent the patient's head from turning during insertion. Desired force vectors should be considered carefully when choosing direct or indirect anchorage. Indirect anchorage allows the clinician to apply a force vector similar to conventional orthodontics while enhancing the stability of the MI. Direct anchorage may be more beneficial for certain types of tooth movement, such as molar intrusion or en masse anterior retraction, where it can provide an intrusive component of the force vector that will help control the vertical dimension.

Design factors: A high-pitch design with surface treatment (such as sandblasting) is recommended for best stability. In addition, the following factors should be considered when choosing an MI:

- Theoretically, a wider MI provides greater stability. In interradicular spaces, however, a wider MI risks root contact. MIs with a diameter of 1.2-1.4mm are narrow enough for most interradicular sites and have been shown to achieve high clinical success rates.
- A tapered shape seems to provide greater stability than a cylindrical shape (as seen in greater bone-to-implant contact and greater maximum insertion/removal torque), but a sharply tapered design may not be advisable because it can require more insertion pressure to place with the self-tapping/drilling method, due to the wider diameter at the head.
- Even an experienced clinician may not be able to perform a perfectly stable and correctly angulated implant placement when using a long MI, which increases the risk of bone damage during insertion. Therefore, for most uses, the recommended MI length is 6-8mm, just enough to engage cortical bone and approximately half of the total buccolingual alveolar bone width.

Thorough home-care instruction is also essential to maintain the late stability of MIs. Because an MI is usually smaller than a restorative implant, it is more prone to loosening if the patient accidentally hits the implant with a toothbrush head or a hard piece of food. Good hygiene around the implant is important.

Do not look for an opportunity to place MIs; look for situations where treatment is not possible or is compromised without using them!

ROBERT BOYD, DDS, MED
JOOROK PARK, DMD, MSD
San Francisco, CA

I believe the most important factors in determining skeletal anchorage success are the skill, confidence, and experience of the clinician placing the temporary anchorage device. I would suggest that, in most instances, failures can be traced back to a lack of primary stability at the time of placement. Attempts to place miniscrews in areas of difficult access, wobbling during insertion, and pilot-hole drilling often result in lack of primary stability and, ultimately, miniscrew failure. Secondarily, clinicians must take care to avoid overloading miniscrews. While research seems to indicate maximum acceptable forces in the range of 250-300g, I have had tremendous success using nickel titanium springs delivering a constant, predetermined force of 150g.

STEPHEN TRACEY, DDS, MS
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Factors leading to success:

- Primary stability
- Screw placed in attached gingiva
- At least .5mm of bone on each side when placed in interradicular space
- Quantity of cortical bone
- Operator's experience

FLAVIO URIBE, DDS, MDS
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Most failures occur during the first four months after placement. Therefore, surgical skill is of the utmost importance for success. The minimization of bone damage during placement has a key role. The next main factor contributing to failure of orthodontic micro-implants is root contact; if the micro-implant meets the root during

placement or as a result of tooth movement, mastication can disturb the implant, leading to failure. Inflammation is a third important factor. Microimplants placed in the palatal mucosa or attached gingiva have higher success rates than those placed in the mobile oral mucosa. The occlusal force applied to buccal mandibular posterior microimplants might be another cause of failure. Microimplants have shown higher failure rates in this area, even though it has denser and thicker cortical bone than in the maxilla. We have found bending of micro-implants placed in the buccal mandibular posterior area.

HYO-SANG PARK, DDS, MS, PHD
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Poor bone quality, incorrect treatment planning (location), poor oral hygiene and/or inadequate post-treatment care, and pin failures are the most important factors determining the success or failure of miniscrews.

VITTORIO CACCIAFESTA, DDS, MSC, PHD
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The most important determining factor for successful integration of TADs is treatment planning. TADs are just a tool to help anchor specific movements, either directly or indirectly. I have totally embraced TADs in my practice and would encourage potential users to watch their biomechanics for utilization of TADs, more than worrying about how to place them. It will take you a while to start looking at patients with all the possibilities TADs can offer, but just take your time to rethink potential treatment plans. I have especially liked using TADs in adult interdisciplinary cases to close extraction sites without sufficient anchorage or in preparation for restorative work.

Go ahead and tell patients that you are trying something new, and the worst-case scenario with the TADs (they fail) is still the best case without them. Patients will embrace your honesty and give you the chance. Once you have some basic successes, you will feel comfortable with trying more challenging mechanics. Patients understand if you then tell them you have had success with TADs on simple movements and now want to try extraction-site closure, for example, that would have previously required an endosseous implant. Keep your ears and eyes open for possible treatment planning with TADs, and enjoy helping patients in ways you didn't think possible a few years ago.

ROBERT S. HAEGER, DDS, MS
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Success with miniscrews is determined clinically by achievement of a particular treatment objective. In other words, has the miniscrew anchorage "survived" to provide the necessary support for the applied biomechanics? Failures of miniscrews appear to be multifactorial, with no absolute consensus on the causes. It seems that location, location, location is critical, not only in terms of adequacy of interradicular space and type of tissue insertion (through or immediately adjacent to the attached gingiva is usually preferable) into "solid" cortical bone, but also in the selection of appropriate sites for easiest insertion with least chance of error, best biomechanical advantages, and facilitation of oral hygiene.

The premature loss of miniscrews is a disconcerting and unpredictable reality that we must embrace—especially since no one type of screw has been demonstrated to exhibit a significantly lower failure rate. Many reports blame "root proximity" as the primary cause for loss, but interestingly enough, there are a substantial number of successful clinical results where screws were obviously in contact with roots, or at least in periodontal spaces. There may, in fact, be a difference between the early loss of a screw that has been inappropriately inserted adjacent to or into the periodontal space compared with success when the root is moved into contact with the screw and/or the screw is moved ("tipped") into the adaptable periodontium.

In conclusion, operator skill and experience in selecting appropriate locations and inserting screws correctly, combined with good-quality bone (adults lose fewer screws than adolescents), healthy soft tissue with good healing potential

(medical history), and appropriate oral hygiene are factors favoring the odds of more successful results with miniscrew anchorage.

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Narrow interradicular space and tooth contact: Adequate bone is required around the mini-implants to avoid encroachment into the periodontal ligament. Teeth respond to occlusal forces by minute movements within their sockets, which may lead to disruptive force that can cause mechanical dislodgement of the mini-implant if root contact occurs.

Surgical technique: Non-traumatic placement with proper insertion torque and speed is essential for primary stability. Because bone is viscoelastic, too much force will compress it around the advancing mini-implant.

Inflammation: This is often caused by mechanical irritation or bacterial infection, which can lead to a surge of cytokine release during the inflammatory response, elevating bone turnover rates. Consequently, bone resorption around the mini-implant will loosen the anchor units.

Thickness of soft tissue: A larger contact area between the bone and mini-implant leads to a greater stability. Since thicker soft tissue reduces this contact, proper selection of mini-implant length is important, especially in the palatal slope area of the palate and the retromolar area of the mandible.

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Placement location: Thickness of the cortical plate and the length of the TAD are important success factors. Placement in fixed rather than mobile tissue is critical, and for torsional requirements, right- or left-handed threads are necessary.

TAD design: There are many different manufacturers of TADs, but I prefer the type that has a raised collar that seats against the cortical plate. These seem to have a better success rate.

I prefer to have someone else place the TAD. The failure rate is still too high, and if I place the TAD, I'm married to it. There are recent reports of a 25% failure rate, which makes my point—although my experience is lower, maybe 10-15%.

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The insertion site appears to be the most important factor determining the success of miniscrews. Our patients have shown significantly different success rates in different insertion areas: the anterior palate has a success rate of more than 97%, whereas the mandibular lingual aspects, the retromolar areas, and interradicular insertion between incisors have success rates of 60% or less.

The morphology at the specific insertion site is also important. A miniscrew placed in a location that has a characteristically higher success rate—e.g., between the lower second premolar and first molar—is more likely to fail if inserted too high or too low. We have found the ideal insertion site to be the mucogingival junction, within the attached gingiva, with a slight apical angulation of the screw. But even miniscrews in these well-chosen insertion sites can be troublesome when placed by an operator with inferior skill, knowledge, and experience. For example, the failure rate increases significantly with incorrect screw diameter or length, an insertion technique that compromises primary stability, or improper loading forces and vector biomechanics.

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