State of the art of miniscrew implants: An interview with Sebastian Baumgaertel

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Dr Baumgaertel is an assistant clinical professor at Case Western Reserve University in Cleveland, Ohio, and director of the subspecialty clinic for skeletal anchorage. He also maintains an active private orthodontic practice. He has lectured nationally and internationally on orthodontic mini-implants and cone-beam computed tomography. He has published many scientific articles and is coeditor of the textbook *Mini-Implants in Orthodontics—Innovative Anchorage Concepts*. He serves as a member of the editorial review board of the *AJO-DO* and acts as ad-hoc reviewer for several other scientific dental journals. (Am J Orthod Dentofacial Orthop 2009;136:277-81)

Robert P. Scholz: What are the major changes you have seen in the development of temporary anchorage device usage in the United States?

Sebastian Baumgaertel: The use of miniscrew implants for skeletal anchorage has clearly become more widespread. Although initially miniscrews were used only in cutting-edge private practices and some academic institutions around the country, they have become rather mainstream today. This is probably due to strong evidence that orthodontic mini-implants really do provide the much-desired absolute anchorage.[1-4] I doubt that there is an orthodontist in the United States who hasn't heard of skeletal anchorage or absolute anchorage.

Practitioners have grown more experienced and sophisticated. The initial "black-and-white" decision making that was often a consequence of lack of experience is beginning to disappear. One example is that miniscrew implant placement has become more evidence-based. For example, in the beginning, practitioners thought that placement was complicated and that predrilling was always required. Later, the predominant notion was that, with a self-drilling pin, one never predrills. Of course, this is also not entirely correct: even though predrilling is technically obsolete when a self-drilling miniscrew is used, studies suggest that the proper implant site preparation should be a function of local anatomy rather than screw design.[5] This more balanced evidence-based approach is starting to permeate the orthodontic community. Another example is that biomechanics have become more sophisticated. Initially, we saw predominantly direct-anchorage biomechanics. These are simpler and thus popular with beginners. Unfortunately they come with "hidden" force vectors and are not fail-safe. As an alternative, indirect anchorage has become increasingly popular. Today, experienced clinicians tend to use both direct and indirect anchorage biomechanics when necessary. This is another example of the reduction in "black or white."

RPS: A recent survey[6] showed that only 43% of orthodontists place their own miniscrews; the rest refer to oral surgeons or periodontists. Do you think most orthodontists should place their own and why?

SB: That decision should be made by the orthodontic practitioner. It depends on several factors such as comfort with surgical procedures, practice management, referral network, and so on. There is no right or wrong way to proceed. From personal experience, I know that many orthodontists prefer to refer the initial patients to a surgical colleague for placement. This is an excellent way to begin, since it allows the orthodontist to become acquainted with the use of miniscrew implants without having to worry about the surgical procedure. In the long term, practitioners who are serious about implementing mini-implants into their practices will probably choose to perform the placement themselves. This is typically logistically preferable, avoids miscommunication between clinicians, potentially reduces the costs of the procedure, and allows for immediate loading. With the orthodontist placing the miniscrew, it usually ends up where he or she requires

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it. In other words, the results tend to be more precise, and this facilitates biomechanical applications. I predict that the number of orthodontists performing this simple surgical procedure themselves will increase to an even greater percentage in the coming years.

RPS: How can an orthodontist learn to place miniscrew implants?

SB: A number of good textbooks are available that deliver a solid knowledge base, and the current dental literature has an impressive amount of articles. Those, however, are no substitute for a seminar given by an expert on the subject. The better courses even offer hands-on training. Finding an experienced colleague who is willing to mentor a beginner through the process is also a great way to start.

RPS: Do you see an increase in miniscrew training in our postdoctoral orthodontic programs?

SB: Yes. This is also necessary because absolute anchorage through orthodontic mini-implants is not a fad but a successful evidence-based orthodontic treatment method that delivers good results and, thus, is here to stay. To maintain the high standard of postgraduate orthodontic education in the United States, miniscrew implants should become an integral part of a program's curriculum. As an orthodontic educator, I also know that it is easier to train residents who are fairly fresh out of dental school or general dental practice in the use of miniscrews than to train experienced orthodontists who have not performed any surgical procedures in years. However, at the same time, I have noticed a tendency for residents to overuse miniscrew implants. I mean that miniscrews are being used in patients in whom traditional biomechanics would have yielded comparable results. This ultimately carries the risk of creating 1-dimensional orthodontists with a limited arsenal of biomechanical solutions to a problem. The residency should be the place to learn and master all sorts of high-anchorage methods from Tweed-style anchorage preparation and headgear use to absolute anchorage with orthodontic mini-implants. I am therefore an advocate of a structured, conservative protocol with clear-cut indications for mini-implant use during orthodontic postgraduate education.

RPS: What type of radiographic imaging is necessary for miniscrew implant placement and does this vary with the location of the device?

SB: There is no question that it varies with the location of the placement site. To me, 3-dimensional cone-beam computed tomography (CBCT) imaging is the best option. The amount of information you can extract from a CBCT scan is incredible. You can measure nearly all the variables you are interested in when placing a miniscrew: root distance, cortical bone thickness, overall bone volume, placement angle, and so on. However, a CBCT scan is not a prerequisite for successful miniscrew placement because we have averages available for many of the aforementioned variables that provide clinically useful information.[7-11] The only placement site where I routinely recommend a CBCT scan is at the infrazygomatic crest. Two studies have shown that perforation into the maxillary sinus is likely when seating even the shortest commercially available miniscrew (6 mm) there.[12,13] However, these studies have also shown great individual variations. Therefore, the infrazygomatic crest should not be categorically ruled out as a placement site, but the local anatomy must be assessed on each patient before placing a miniscrew. The palate also has areas with great variations for which a CBCT scan makes sense. However, some palatal placement sites have consistently favorable anatomy.[11] Here, imaging typically does not add much information. The alveolar process requires precise placement of miniscrews between the roots of teeth. At this site, imaging is mainly necessary to assess root divergence. This can be done with a periapical or panoramic radiograph.

RPS: I understand that there are several opinions regarding anesthesia during miniscrew placement. What is your anesthesia protocol and why?

SB: There are basically 2 approaches. The first option is my "biofeedback anesthesia method" or a variation thereof.[14-16] It is based on the fact that bone is not innervated and thus does not require anesthetic. Therefore a potent topical anesthetic is sufficient to numb the gingiva and the periosteum. The advantage of this method is that patients do not feel the discomfort of an infiltration anesthesia, and the sensitive structures in the bone remain fully innervated. If the implant approaches such a structure during placement, the patient will feel pain—a sign that something is not right—and signal this to the practitioner well before actually encroaching on the structure. This is an effective method of preventing permanent damage to sensitive structures during miniscrew implant placement. The other option is infiltration with a traditional syringe or some type of needle-free injection system. These can be uncomfortable in the attached mucosa, especially in the palate. With this method, the anesthetic can penetrate the bone and numb the structures in it. Then biofeedback is all but impossible, and the practitioner must rely solely on his or her clinical judgement to prevent damage to sensitive structures. To me, it is sort of like flying through fog—you never know where the next mountaintop is.

RPS: I have often heard that a miniscrew implant can provide direct or indirect anchorage. Can you explain these terms for us?

SB: Direct anchorage is a biomechanical setup in which a force is directly applied from the implant to a tooth or group of teeth that need to be moved (target teeth). This means that, when using direct anchorage, the target teeth are pulled toward the implant: pulling mechanics result. The clinical consequence—and to me the greatest disadvantage—is that the type of tooth movement dictates the miniscrew implant's location. For example, protraction requires placement of the mini-implant mesially to the target teeth, distalization requires placement distal to the target teeth, and so on. For indirect cases, mini-implants are used to stabilize a group of teeth, creating an implanto-dental anchorage unit. Then, target teeth are moved against this implanto-dental anchorage. In this approach, implant site location is less a function of the desired tooth movement, allowing other important criteria to be considered when choosing the implant site. Both approaches have advantages and disadvantages, and it is up to the treating orthodontist to choose the most appropriate approach for the specific situation. The most important differences are the simple installation and the "hidden" force vectors associated with direct anchorage, whereas indirect anchorage allows for traditional orthodontic mechanics with the difference that a group of teeth is "locked in" and will not move as a result of reciprocal forces. Indirect anchorage, however, is slightly more time-consuming to install.[17,18]

RPS: What criteria would you consider to determine whether miniscrews or bone plates would be best?

SB: It appears that bone plates provide higher success rates than orthodontic mini-implants.[19] They have proven especially useful in the correction of severe open bites and pronounced Class III malocclusions. These benefits notwithstanding, placement is more invasive and requires reflection of a surgical flap along with placing several bone screws.[20] This necessitates referral of the procedure to a surgeon and increases the costs. Therefore, their implementation into routine orthodontic practice will probably be limited to severe malocclusions when miniscrews reach their limits, and miniscrews will remain the anchorage method of choice for more routine applications.

RPS: The failure rate for miniscrews has improved markedly in the past few years. To what do you attribute this improvement?

SB: If you look back at how skeletal anchorage and especially miniscrews have evolved, it is evident that in the beginning this movement was entirely driven by clinicians. The early literature is full of impressive and eye-opening case reports, but true studies and links to the basic sciences such as anatomy and physiology were all but lacking. In orthodontics, clinicians sometimes tend to be right for the wrong reasons. This was true in the initial stages of miniscrew implant use. Clinicians understood the benefits of absolute anchorage. They experienced firsthand that miniscrews can provide absolute anchorage but with frustratingly low predictability and success rates similar to the mathematical expectation of a coin toss. This could be attributed to misconceptions and the implementation of nonevidence-based procedures that only seemed empirically sound, some of which I already mentioned above. Fortunately, academia caught on to the problem and began generating a body of evidence that has substantially increased our understanding of the fundamentals of successful miniscrew implant use—an effort that is still ongoing because many questions still need to be answered.

Some essential information that came to light over the past years has significantly increased clinical success rates. For example, a great improvement is that today we are aware that not all placement sites are created equal and that certain sites have higher success rates because they are anatomically superior, hygiene is easier to maintain, and the sites are more readily accessible for the practitioner, allowing more precise placement.[21,22] We know that miniscrew implants should be placed in a specific torque range and that violation of this rule can have a significantly negative impact on success.[5,23] Root proximity has been identified as a major reason for implant failure, whereas the initial concern of permanent root damage has been rebutted.[24-26] This list could be continued ad libitum with information that just recently was unavailable to practitioners and has a significant impact on success rates.

RPS: There is an opinion that the use of miniscrews will reduce the number of patients requiring orthognathic surgery. Has this been your experience?

SB: I am not aware of any studies on this interesting topic. However, even if there are studies, I postulate that detecting a statistically significant decrease in orthognathic surgery patients because of the advent of miniscrew implants would be difficult—especially if one considers the overall reduction in orthognathic patients as a consequence of greater preference for conservative camouflage treatment approaches and reduced insurance coverage.

From personal experience, I can tell you that usually severe orthognathic surgery cases remain clear-cut orthognathic surgery cases. Miniscrew implants do not work miracles. However, borderline patients can usually be managed predictably with nonsurgical treatment. Overall, miniscrew implants can reduce the invasiveness of orthodontic treatment. Absolute anchorage can often convert an extraction patient into

a nonextraction one. Placing 2 to 4 miniscrew implants is less invasive than extracting 2 to 4 premolars, for example.

RPS: Do you believe that predrilling improves the success rate, or should this be decided on a case-by-case basis?

SB: The need to predrill depends on the thread design of the orthodontic mini-implant and the local anatomy of the placement site: specifically, the thickness of the cortical bone. The bottom line is that predrilling is required when using a self-tapping but nondrill-free thread design. In that case, it is necessary to create a pilot hole that perforates the cortical bone and extends into the cancellous bone the full length of the mini-implant shank. When using a self-tapping, drill-free (self-drilling) thread design, predrilling is optional.[14] Here, predrilling is recommended in areas with thick cortical bone that would otherwise result in too-high insertion torque and the risk of implant fracture or excessive peri-implant bone damage. However, in most cases, this does not need to be a deep pilot hole for the entire length of the implant—perforation of the cortical bone is typically sufficient. Routine predrilling cannot be recommended because this would reduce the primary stability in areas with thinner cortical bone. I will discuss this topic in detail in a forthcoming *AJO-DO* article.[27]

RPS: There is some controversy regarding the design of the miniscrew head. Do you believe it should resemble a bracket or be more generic?

SB: For me, there is no controversy. The answer is that the design of the implant head should depend on the practitioner's preferences. That would be like asking, "What is better, an 0.018-in or a 0.022-in slot?"

Personally, I see no reason not to use some type of bracket head design, though. In addition to allowing the attachment of elastic modules, springs, and chains for direct anchorage applications, those implant heads allow the ligation of a rectangular orthodontic wire. That can be useful when attempting to stabilize a single tooth or tooth segments for indirect anchorage mechanics. Other types of implant heads that are more generic and resemble a ball or a button are mainly designed for the direct attachment of springs, chains, or steel ligatures. Indirect anchorage applications are more difficult to achieve in my experience with those head designs. Some manufacturers offer the same implant with different heads so that a practitioner can use the design that seems most appropriate for the situation. This, however, increases the inventory.

RPS: But I have heard that a bracket-type head introduces more than 1 vector of force and increases the chances of failure. Do we have data proving or disproving this theory?

SB: You are probably referring to the possibility that an implant with a slot in the head can be loaded with torque and that, depending on the biomechanics, it is even possible to create moments at the implant head. This would be a consequence of using the slot for (probably indirect) biomechanics rather than the entire head (for direct mechanics). If the bracket-head miniscrew is used for direct anchorage, there is no difference from any other miniscrew implant. A more precise question would therefore be whether failure rates differ between direct and indirect anchorage. To my knowledge, there is neither any evidence that bracket-type implants have a greater failure rate than implants without a slot in the bracket head nor evidence that indirect anchorage has greater failure rates than direct anchorage. A moment at the implant head is not necessarily negative, by the way; it might even act stabilizing, depending on the direction of the thread and the direction the moment is acting. Of course, indirect anchorage is slightly more involved, and certain rules should be respected when using the slot in a miniscrew implant head. Those depend on the specific head design and are best learned in a seminar taught by an experienced instructor.

RPS: Some recent data have shown that the cortical plate is the main point of purchase. Does this mean that the screw can be shorter?

SB: Perhaps. Data suggest that most resistance to pull-out force is located in the cortical plate, depending on its thickness and the force levels applied.[2,28,29] We have already seen a reduction from the initial 10- and 8-mm screws to 6-mm screws, and I suppose that, on axial loading with orthodontic forces, a further reduction of length could be possible. In case of extra axial loading, however, we also require a certain ratio of extraosseous to intraosseous portion of the implant to ensure mechanical stability: 1:1.5 is generally accepted. This makes 6 mm the shortest length that should be used in clinical practice.

RPS: You have a unique clinical sitation, since you place miniscrews both in your private practice and also at Case Western Reserve University, where all patients are imaged with CBCT. Tell us how having a DICOM file available before placing a miniscrew implant at Case improves your clinical decisions.

SB: I believe that 3-dimensional imaging can be beneficial for identifying the placement site and selecting the proper placement protocol. CBCT imaging gives in-depth information on various important parameters when planning for and placing a miniscrew implant: cortical bone thickness, bone depth, bone density, interradicular distance, and the location of anatomic structures in the bone. The more advanced software packages for CBCT imaging even allow virtual simulation of implant placement.

RPS: Does this mean that every patient receiving miniscrew implants should undergo CBCT imaging?

SB: Probably not. In private practice, CBCT imaging has some shortcomings that need to be considered: slightly increased radiation exposure, acquisition and reconstruction time, and cost. Luckily, many site-specific factors mentioned above have a relatively constant pattern; this means that averages can serve as a good general guideline to implant site selection and preparation. These can be found in the literature.[20-23]

Certain sites, however, have such great individual variation that they should not be used without 3-dimensional imaging. The infrazygomatic crest, for example, has such reduced bone depth that seating even the shortest currently available miniscrew (6 mm) would, on average, cause perforation of the maxillary sinus.[25] However, if the anatomy is favorable, it can be a useful implant site, especially for posterior intrusion. For certain patients, CBCT imaging is invaluable because it aids in the identification of the proper implant site and prevents damage to sensitive anatomic structures.

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