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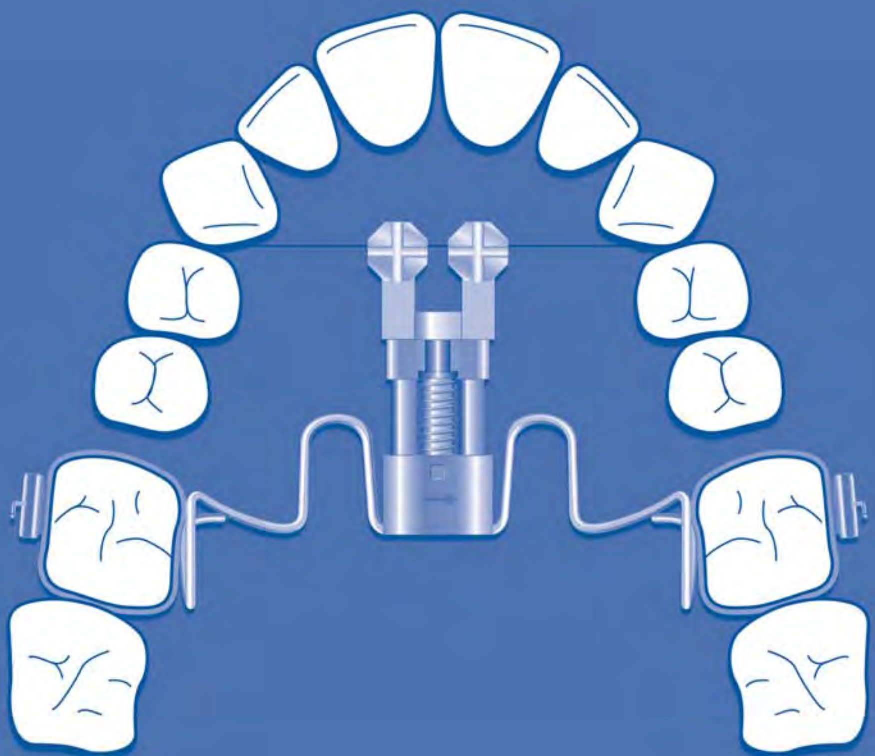
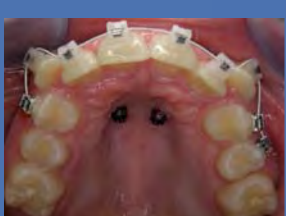
Compendium Miniscrews





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Year after year...

...innovations are introduced in the medical sector that attract a good deal of attention among professionals. In orthodontics, these are sometimes well-known instruments which experience a sudden rebirth of interest due to further development through new materials. However, it is also sometimes due to resources from outside the sector that are found to be applicable in a modified form in orthodontics.

Miniscrews are just such an innovation. Derived from the field of reconstructive surgery, and later finding their way into the dental profession as a support for dental prostheses, these "offspring" from the implant procedure have been accepted in orthodontics for some time now. A seemingly never-ending boom has thus emerged, as regards both the quantity of conference reports (including a few of our own) as well as the plethora of domestic and foreign-published articles. Any orthodontist today who claims to work with state-of-the-art procedures has most certainly already found the application of these specialised screws to be indispensable.

Really? The vast quantity of publications, in which follow-up tests were carried out regarding the stability of these screws, shows that there does indeed exist a huge interest in experimentation, nevertheless, it has not yet been completely proven what exactly the limitations of these screws are. Loss ratios of up to 100% for lingual insertion indicate the need for more investigation. But when the screws remain stabile, they have proven to be a godsend for anchorage.

It is unfortunately also not true that a miniscrew is capable of superseding the laws of biomechanics. If it is not clear to an individual why certain dental mechanics are not successful in moving tooth XY to its desired location, then the implementation of a screw will not be of assistance.

Is this a superfluous argument? By no means, since the manifold possibilities for an expedient application of miniscrews can actually enable actions which have previously not been possible (or only possible with considerable costs for materials). They can decrease, with proper indication, the length of time for treatment, thereby representing an improvement for the spectrum of orthodontic treatment-something which should not be ignored. Since the implementation of a screw amounts to a surgical intervention which many doctors have not used for many years (or even since their studies), it can be considered a "must" to inform oneself prior to application of this tool. For this purpose, this booklet offers a contribution in that it can inform one regarding the indications, possibilities and procedures for the implementation of miniscrews. Even though it is quite comprehensive, it cannot replace continuous on-going training in this area; these screws are still at the beginning stages of their scientific application.

Even the longest journey begins with that first step. So let us then encourage you to join us in this journey. As a reward, you can expect to find both excellent ideas to help solve previously unsolvable problems in treatment, as well as more satisfied patients!

Dr. Björn Ludwig,
Dr. Bettina Glasl, Dr. Thomas Lietz,
Prof. Dr. Jörg A. Lisson and Cornelia Pasold

The presence of numerous publications, courses and advertising material on miniscrews may lead to the assumption that these are ubiquitous. After gaining more insight into daily practice, however, it becomes apparent that the reality is quite different. There are surely various reasons why miniscrews are not yet in daily use in many practices. With this series, the authors wish to encourage hesitant practitioners to use miniscrews on a routine basis by providing a compendium of experience and new findings in this field.

Miniscrews — a landmark in dental practice

Part I: The basis and history of anchorage, the selection of screws

By Dres. Björn Ludwig, Bettina Glasl, Thomas Lietz and Professor Jörg A. Lisson

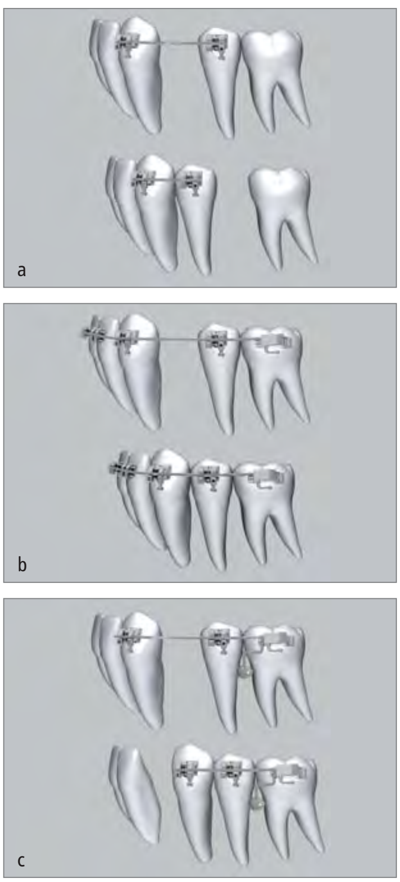

Fig. 1.1: After removal of the first premolar, the canine is to be retracted; results for **a):** minimum, **b):** medium or reciprocal and **c):** maximum anchorage.

Anchorage in general

Moving a body requires anchorage in form of a counter bearing. The force required for the movement acts on both body and abutment. In his Third Law (1687), Newton specified that every action has an equal and opposite reaction. In dentofacial orthopaedics, this means that, with regard to the dental support of tooth movement, the force acts on all teeth involved. Both bodies ultimately move. The extent of movement and countermovement does, however, depend on the anchorage strength of the individual teeth, i.e. on the number and length of the roots, the root surface and the structure of the surrounding bone.

Anchorage quality can be divided into three categories:

1. minimum anchorage
2. medium anchorage
3. maximum anchorage.

These three mechanisms can be descriptively explained using the example of a conventional canine retraction after removal of a first premolar (Fig. 1.1).

In case of minimal anchorage, the individual teeth provide the support. Figure 1a shows that a single premolar is not sufficient as an abutment to distalise a canine. The premolar is clearly mesialised in reaction to the application of force. Figure 1.1b shows how two equally strong anchorage segments are formed. Action and reaction are comparable in this case: the result is a reciprocal tooth movement. In case of maximum anchorage (Fig 1.1c), the posterior group of teeth is secured and made stationary by using a miniscrew. The canine can be retracted by the complete force vector, as the reactive force is completely absorbed by the anchorage block formed.

Apart from the anchorage quality, the basis, i.e. the type of anchorage location, also gains importance:

1. dental or desmodontal support:
- additional intra-oral devices (nance, palatinal arch, lingual arch, lip bumper)
- modification of the fixed appliance (buccal root torque, blocking)
- incorporation of teeth of the opposite jaw (Class II or III elastic bands)

2. extra-oral support:
- headgear
- face mask

3. enossal support:
- implants, miniscrews, etc.

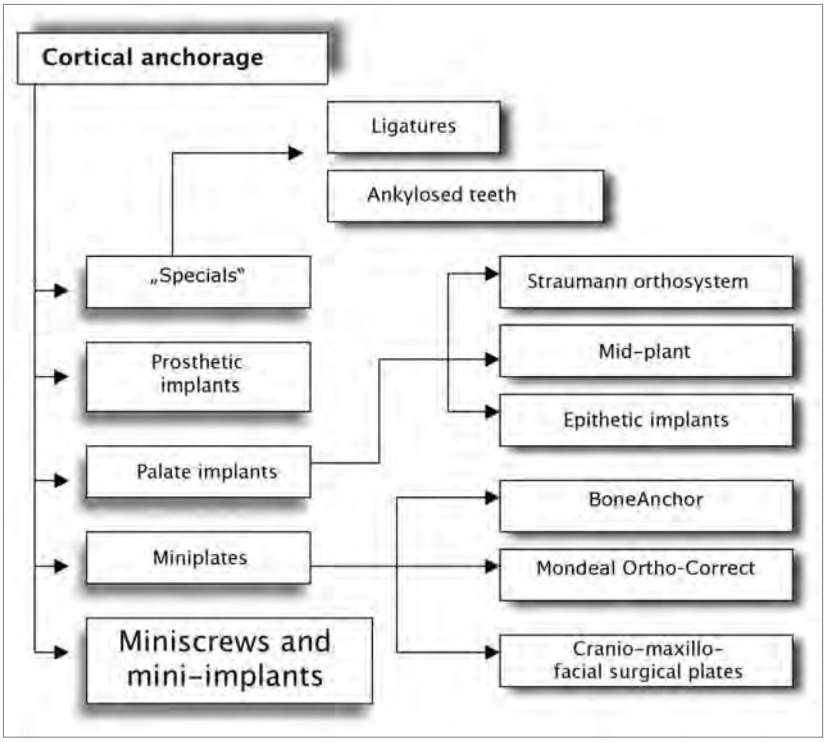

Fig. 1.2: Overview of the range of cortical anchorage options.

This article only deals with anchorage in bony structures. The terms “skeletal or cortical anchorage” are synonymous in this case (Fig. 1.4).

History and overview of skeletal anchorage

The era of bony anchorage began in 1945, when Gainsforth tried to insert screws into the jaw bone as load anchors. Many experiments were unsuccessful and the method had become increasingly obsolete by the late 1970s. From 1980 onwards, various research groups (such as Creekmore, Roberts and Turley[2-7]) took up the subject once more. Creekmore published the first, clinically successful patient treatment case.

There are now numerous options for cortical anchorage, ranging from (artificial or pathologically) ankylosed teeth, the basis of miniplates normally used in cranio-maxillo-facial surgery, to the use of prosthetic implants (Fig. 1.3). Wehrbein & Glatzmaier were the first to present an implant system specially designed for dentofacial orthopaedics (Orthosystem, made by Straumann[8-10]). These orthopaedic jaw implants which, apart from Orthosystem, also included Midplant (made by HDC) are mainly inserted into the palate. This method is both safe and successful. In recent years, the requirements for cortical anchorage techniques have been defined in the literature. However, under closer inspection, only orthodontic mini-implants met the requirements:

- biocompatibility
- small size
- simple to insert and use
- primary stability
- immediate load capacity
- adequate resistance against orthodontic forces
- can be used with standard orthopaedic appliances
- independent of patient cooperation
- clinically better results in comparison with standard alternatives
- simple to remove
- cost-effective.

Mini-implants

Each form of skeletal anchorage, including miniscrews, is by definition an implant: “An implant is an artificial material implanted into the body, which is to remain there either permanently or for an extended period.”

More than thirty different terms for orthodontic screws are used in the international literature. The most common ones are mini-implant and miniscrew, while the expressions “minipin” or “pin” are preferred when speaking to patients. By now there are over thirty manufacturers of miniscrew systems (Fig. 1.5). The number of screws per system can range from two to 154 different types. To help practitioners in daily practice, the most important decision-making criteria for choosing implant systems are discussed below.

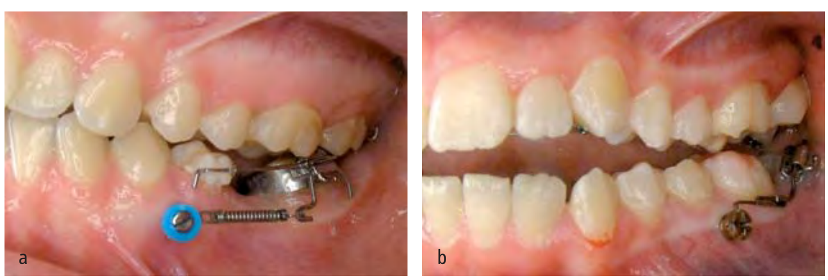

Fig. 1.3: Clinical example of two typical miniscrews treatment applications: **a):** gap closure, **b):** uprighting of 2nd molar.

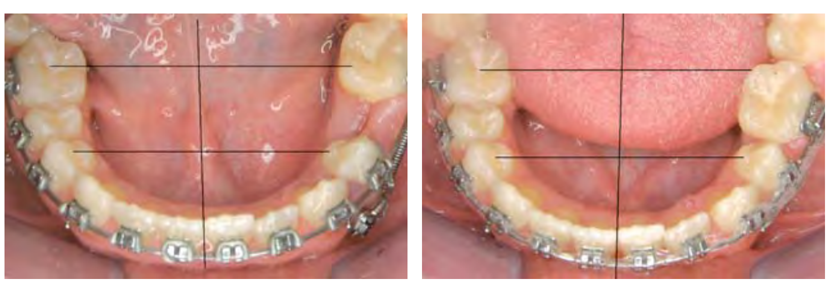

Fig. 1.4: One-sided gap closure in the left lower jaw. The expected reactive side-effect of subsequent shifting of the middle line did not result thanks to the skeletal anchorage.

Fig. 1.5: Eight examples from the total of over 700 different forms of miniscrews currently available (from left to right): OrthoEasy® (FORESTADENT), Aarhus Mini Implant (Medicon), AbsoAnchor (Dentos), Dual-Top™ (Jeil Medical), LOMAS (Mondeal), Osas (Dewimed), Spider Screw® (HDC), tomas®-pin SD (DENTAURUM).

Material

All miniscrews are made from pure titanium or from an alloy of titanium with aluminium or vanadium. This is appropriate, as the biocompatibility of such materials, the metal surface of which is in direct contact with the bone, has often been proved.

Osseo-integration

Branemark was the first to define the concept of osseo-integration, which he termed “a direct functional and structural link between living bone tissue and the surface of a force-absorbing implant”.[15-17] Several authors, such as Costa and Maino, see the aim of anchoring a miniscrew not in osseo-integration, but in their use as a skeletal anchorage.[18,19] In the opinion of Cope and Bumann, miniscrews are anchored by mechanical retention and not by osseointegration.[20,21]

Diameter of the miniscrew

The diameter of the miniscrews on the market varies between 1.2 and 2.3 mm. The information about the diameter of a screw normally refers to its outer diameter, i.e. the size of the shaft, including the thread. For secure and primarily mechanical anchorage, a certain amount of bone is required around the screw. To date there have been no studies on the amount of bone actually required; the information available varies from 0.5 to 2 mm. At an interradicular level, the amount of space available prescribes the maximum diameter of the screw.

Publications by Poggio et al.[22], Schnelle et al.[23] and Costa et al.[24-25] provide some clues as to the vertical space required, i.e. the space between the enamel/cement interface and the mucogingival line. These investigations clearly show that the diameter of a miniscrew should not exceed 1.6 mm. The stability of a miniscrew in the bone depends on its diameter and not on its length.[26-27]

Length of the miniscrew

The length of the miniscrews on the market varies between 5 and 14 mm. The information about the length of a miniscrew usually refers to the shaft, i.e. the threaded section.

Like the diameter, the length of the screw selected depends on the amount of bone available. Depending on the region, the total thickness of the bone is between 4 and 16 mm[28] (Fig. 1.7). The length of a screw is of secondary importance when it comes to secure anchorage as described above. Various investigations have shown that it is the thickness of the cortical section that plays a more important role.[29-31] As far as the distribution of force over the body of the screw is concerned, FEM analyses have shown that the load is applied only in the region of the cortical bone.[32-33]

When selecting the length of the screw, the depth of the gingiva must also be taken into account, with an average layer depth of 1.25 mm. Thus the ratio between the length of the head (the part of the screw outside the bone) and the length of the threaded section (the part of the screw inside the bone) should be at least 1:1. Poggio et al.[22] recommend lengths of 6–8 mm. Costa[24,25] finds miniscrews with a length of between 6 and 10 mm acceptable. On the basis of these investigations, it would appear that it is not

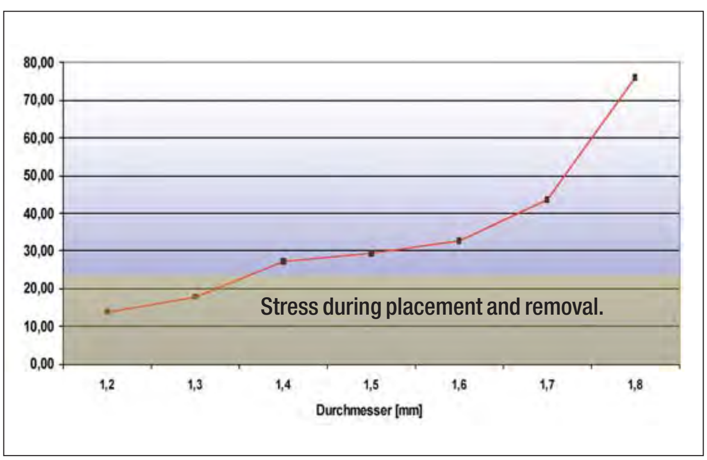

Fig. 1.6: The stress resistance (fracture level in Ncm) depends on the diameter of the miniscrew (according to Kyung, modification by the authors).

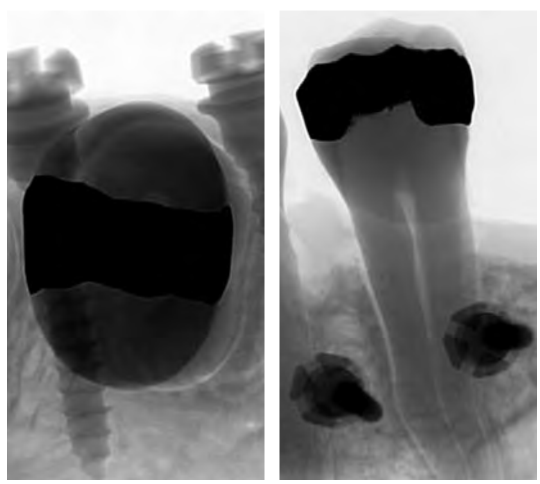

Fig. 1.7: Interradicular X-ray image showing spatial ratios.

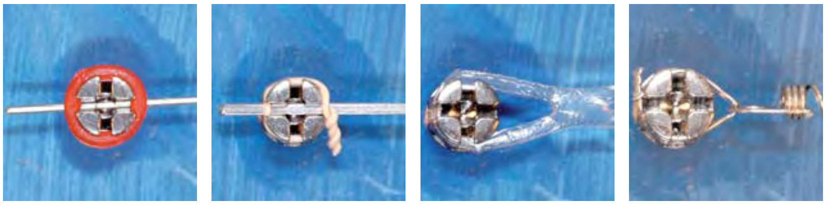

Fig. 1.8: For practical reasons, it is advisable to use systems that offer only one, universally applicable head variant. However, this one head should make it possible to attach all types of link elements (threads, elastic chains, round wires, square wires).

necessary to use longer screws. This has been confirmed by numerous clinical experiences. The clear colour-coding of the screws for visual distinction of length and diameter is helpful, and this can be provided by means of anodisation, for example (OrthoEasy®, FORESTADENT). An additional positive side-effect is that the oxide layer results in firmer anchorage of the implant in the bone.[34]

Screw head

Some suppliers have a special head variant for each potential application in their range. Thus there are functional heads with:

- hook tops
- ball-shaped heads
- eyelets
- simple slots
- cross-shaped slots
- universal heads (Fig. 1.8).

The screw head should be very small and compact, to ensure that the patient experiences minimal discomfort. On the other hand, the head must be large enough so that the coupling elements can be securely fastened to it (Fig. 1.9).

Transgingival section

The transgingival portion, also known as the gingival neck, is the most sensitive part of an implant or a miniscrew. The perforation of the gingiva provides a potential access route for micro-organisms, posing the risk of peri-mucositis or peri-implantitis. This can be one of the main causes of the premature loss of miniscrews.[35-36] During the immediate post-operative phase, the mucosa should be as close as possible to the screw to seal the area.[37] The most advantageous shape is that of a cone, as this shape naturally results in safe sealing without a pressure zone. This makes it more difficult for micro-organisms to penetrate and prevents infections. The cone shape also seals the perforation wound, as a cork would seal a bottle, thus reducing bleeding.

Conclusions

The correct method of anchorage with regard to shape and quality is decisive for successful treatment. Maximum anchorage is not vital in all cases, so that the use of a mini-implant is not necessarily essential. From an historical point of view, the cortical anchorage system is, in common with other orthodontic techniques, not new at all. The idea was conceived more than 75 years ago. Of all forms of skeletal anchorage, the mini-implant is the most universally used and is most suitable for routine use. However, before practitioners can select the most appropriate miniscrew for use in their practice from the large range on offer, it will be necessary for them to study the existing literature.

Fig. 1.9: Height difference in two clinical situations to demonstrate the height of the screw head.

Miniscrews —
a landmark in dental practice

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Editor's note

Concerning the article series "Miniscrews —a landmark in dental practice" a reference list can be requested. Please contact:

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Part II: Basic information on the insertion of miniscrews

Preparing for insertion

The insertion of a miniscrew is a very simple and rapid therapeutic measure. Successful insertion only requires adherence to a few—but important—principles. There are certainly several methods that will yield good results. The following text concentrates on those insertion steps that provide a high degree of safety to patient and dentist (checklist for insertion). This general information must, of course, be adapted to individual circumstances.

Checklist for insertion

Pre-operative planning and preparation
- Planning documentation (X-ray, situational models)
- On the model: marking of the muco-gingival line, tooth axes and determining the point of insertion
- Sterilisation of the instruments; preparation of the workstation

Anaesthetic/assessment of the site of insertion
- Anaesthetic
- Measuring the thickness of the mucous membrane (optional)
- Use of X-ray aids
- Control image

Selection of the screw
- Determining the length
- Determining the type of screw

Transgingival penetration
- Excision of the mucous membrane or perforation with the screw

Preparing the bone site
- Optional marking of the bone
- Perforation of the cortical bone or deep pilot drilling, depending on the type of screw

Inserting the miniscrew
- Manually or by machine

Start of orthodontic measures
- Attaching and fixing the linking elements

Aftercare
- Notes on care and behaviour
- Check-up dates

Removing the miniscrew
- Removing the linking elements
- Removing the miniscrew

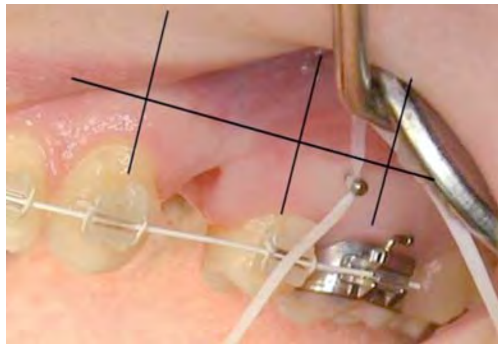


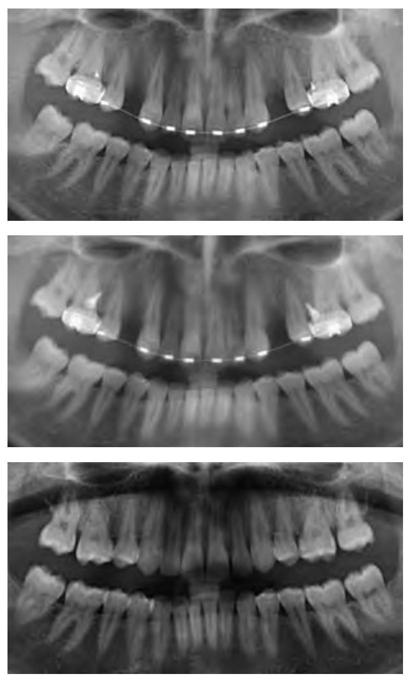
Fig. 2.1: X-ray positioning aid (a so-called "X-ray pin" made by FORESTADENT in Pforzheim, shown in situ, in relation to the adjoining tooth axes.

General notes on insertion

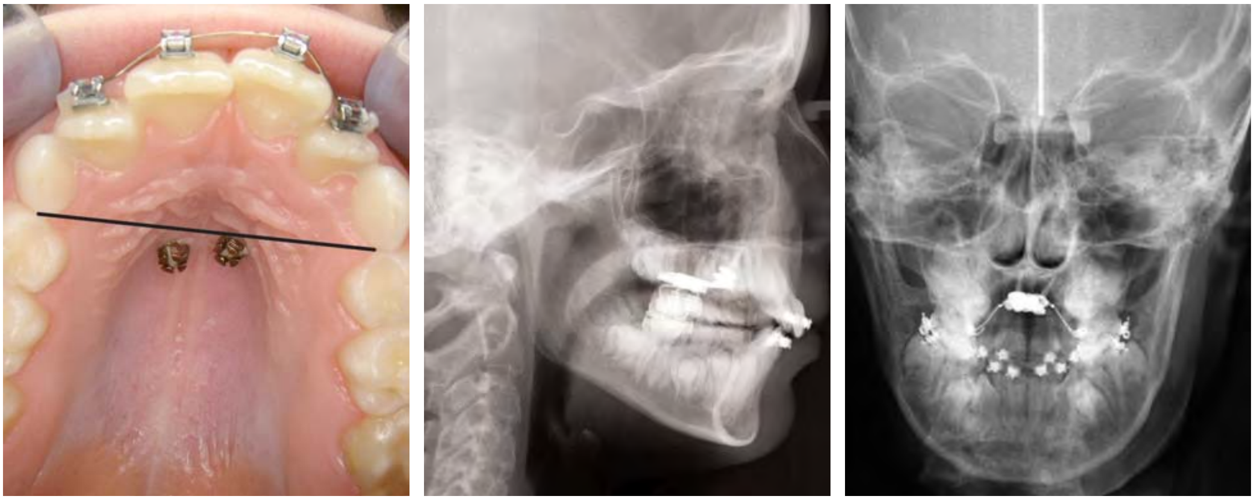
The basic requirement for successful treatment with miniscrews is accurate pre-operative planning. This also includes a comprehensive anamnesis and an accurate assessment of the findings. The patient must have the treatment explained to him/her (medical history and patient information forms are available by e-mail from praxis@kieferorthopaedie-mosel.de).
Proper hygiene must be ensured during the entire operation. Both the dental chair and the work on the patient must be prepared regarding this. During the insertion of a miniscrew, adherence to all hygiene measures required for an invasive procedure, such as a sterile work environment, gloves, etc. must be ensured. All instruments required for insertion must be checked for completeness, functionality and sterility. The patient may optionally rinse with a disinfectant solution, or a suitable disinfectant can be locally applied. The patient is then positioned in a way that a clear view of the operational area is provided and insertion is ergonomically facilitated for the treating dentist.

Preoperative planning

To function correctly, a miniscrew requires firm anchorage in the bone (primary stability) and the positioning of its head in the denser gingival tissue (gingiva alveolaris). The selection of the insertion location must take clinical and paraclinical findings into account (X-ray image, model), as well as the goal of the treatment and the resulting orthodontic appliance. For inter-radicular insertion, there must be a bone thickness of at least 0.5 mm around the miniscrew. This means that for a miniscrew with the—for many reasons—optimal diameter of 1.6 mm, the roots must be at a distance of at least 2.6 mm from each other. Thus the bone status along the longitudinal axis of the point of insertion must be carefully evaluated. Basic information in this regard is obtained by carrying out measurements on the model. It often helps to mark the vertical axis of the teeth and the progression of the muco-gingi-



Figs. 2.2: The top image shows the initial situation. An X-ray pin was inserted into each of the first and second quadrants of the upper jaw (in the 6–5 region) to check the bone site, followed by the miniscrew. Both screws were inserted in a manner that is clinically safe, but the X-ray images show damage to the adjoining root in the right-hand quadrant, indicating a false-positive initial interpretation of the situation



Figs. 2.3: The clinical image shows two miniscrews inserted into the palate in the safe zone to the distal side of the transversal line linking the two canines. The FRS and the PA image confirm the bone support in the insertion region.

val line on the model, based on the clinical and radiological findings. This will allow for a better assessment of the spatial circumstances in combination with the X-ray image. To ensure the accurate determination of the insertion site, X-ray aids (Fig. 2.1) are available. Their use may facilitate the selection of the insertion site, but cannot replace the other diagnostic measures. It should be borne in mind that, depending on the positioning of the X-ray tube, the X-ray object and the X-ray film and/or sensor, all types of X-ray devices and images may provide some optical distortion. Interpretation of images can thus lead to false-negative or false-positive results (Fig. 2.2). For this reason, the placement of a miniscrew should always be based on the clinical findings. If a miniscrew is to be inserted into an area in which there is no risk of damage to roots, nerves or blood vessels (e.g. into the palate just behind the transverse line linking the two canines), the position of the screw may be freely chosen (Fig. 2.3).

Anaesthetic

During the interradicular insertion of a miniscrew, the sensitivity of the periodontal tissue of the adjoining teeth should be retained. For this reason, the following two procedures can be recommended

a) Low-dose injection of approximately 0.5 ml anaesthetic (Fig. 2.4)
b) Induction of superficial anaesthesia of the mucous membrane at the insertion site. A topical anaesthetic gel is suitable (Fig. 2.5). No general anaesthetic is ever required for this procedure.

Choice of type of screw

Measuring the thickness of the mucous membrane (optional)

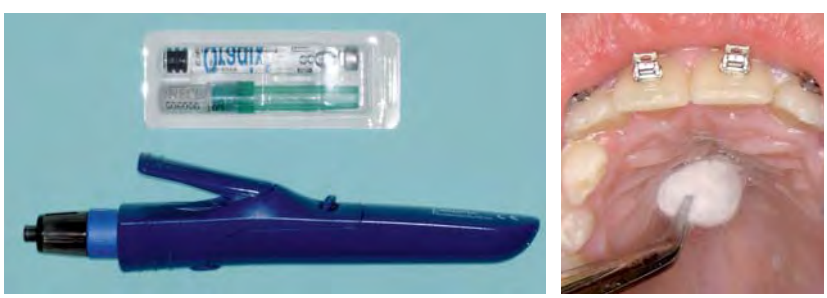
A pointed sensor with an attached rubber ring is used to measure the thickness of the gingival tissue in the direction of insertion (Fig. 2.6). This information may be useful when determining the final length of the screw and possibly when inserting the miniscrew. When choosing the length, the bone repository and the thickness of the mucous membrane in the direction of insertion play a role; in the retromolar section of the lower jaw and in the palate, the thickness of the mucous membrane is often more than 2 mm. The part of the miniscrew inside the bone must be at least as long as the part outside the bone. The various dimensions must be taken into account.

The thickness of the bone in the planned direction of insertion determines the required length of the miniscrew:

- Bone thickness > 10 mm: miniscrews with a length of up to 10 mm are to be used
- Bone thickness < 10 mm and > 7 mm: miniscrews with a length of 8 mm or 6 mm are to be used
- Bone thickness > 6 mm: miniscrews cannot be used.

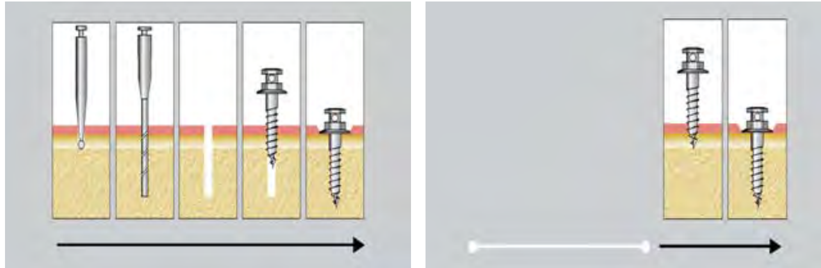
The following guidelines can be used when selecting the length:

Figs. 2.4: Injection pen with needle and anaesthetic cartridge.



Figs. 2.5: Superficial anaesthetic device in pen form, with cartridge.

Fig. 2.6: Measuring the thickness of the mucous membrane in the direction of insertion. *(Photo: Dr. Pohl)*



Figs. 2.7: Diagrams showing the thread mechanisms: **a)** self-cutting; **b)** self-tapping.

Figs. 2.8a, b: Pre-drill with a 4 mm long blade and limit stop: **a)** Drill (FORESTADENT); **b)** tomas®-drill SD (DENTAURUM).

Fig. 2.9: Sterile miniscrew supplied in pin-holder (tomas®-pin [DENTAURUM])

- in the buccal region of the top jaw: 8 mm or 10 mm
- in the palatinal region (depending on the region): 6, 8 or 10 mm
- in the lower jaw, usually 6 mm or 8 mm.

Determining the type of thread

Self-cutting miniscrews require predrilling (also known as pilot drilling) appropriate to the length and diameter of the screw as well as to the quality of the bone. A self-tapping miniscrew will find its own way into the bone and requires no pre-drilling (Fig. 2.7). Bone is more or less elastic depending on site, age and structure. However, the screw diameter, the thickness of the cortical bone and the hardness of the bone at the insertion site limit to what extent this method can be used. Without predrilling, the bone is strongly compressed during insertion and will suffer the corresponding tension stress. This may result in cracking of the bone around the implantation site. When the screw is screwed into the bone, it is subjected to high loads. Depending on the bone quality, the resistance against insertion and the continuity of the rotational movement, high torsional forces can result. In regions with thick cortical bone and a much looser bone structure (e.g. the upper jaw), the use of self-tapping screws can be recommended. In the opposite case, i.e. if the cortical bone is thick and the bone structure is solid (e.g. anterior lower jaw), both self-cutting and self-tapping screws may be used, in each case after previous perforation of the compact.

Transgingival penetration

The miniscrew must necessarily penetrate through gingival tissue, which must thus be perforated during insertion. Nowadays, two methods are used for the perforation of the gingival tissue: a) excision of the gingival tissue or b) direct insertion of the screw through the gingival tissue. There are currently no published studies that investigate the effect of these two variants on post-operative problems, histological effects and/or the loss rate of miniscrews.

Preparing the bone site

An important aspect is the protection of the bone. Insertion without a predrilling results in tensional stress within the bone. This may, in turn, lead to post-operative complications. Particularly in the case of crestally placed screws, the bone displacement may result in a severe expansion of the periosteum. The thickness of the cortical bone, especially in the lower jaw, has a not insignificant effect on the torque of the screw. To ensure that the screw is not overloaded during insertion, the compacta of the anterior lower jaw should be perforated by predrilling, as mentioned ear-

Figs. 2.10a–d: Preparing the work rack and removing the blades.

Figs. 2.11: Removing the instruments and insertion of two miniscrews into the palate by machine.

lier. Predrilling should take place at a maximum of 500 rpm, using a short pilot drill and water-cooling to reduce the risk of damaging the root (Fig. 2.8).

Inserting the miniscrew

It must be ensured that the miniscrew is removed from its sterile packaging (Fig. 2.9) or the work rack (Fig. 2.10) without contamination. The thread of the screw may not be touched. The screw should be inserted at a constant rotational speed (at approximately 30 rpm) and with as uniform a torque as possible. Both manual insertion and insertion by machine are shown in a series of images below.

Manual insertion

Many manufacturers provide various screwdrivers and blades in several lengths for the manual insertion of the screws. Because of their dimensions, long blades pose the risk of attaining a very high torque during insertion. Thus insertion must be carried out carefully to avoid breaking the miniscrew. Torque ratchets are available for use with some systems (e.g. tomas®, DENTAURUM; LOMAS, Mondeal), which provide a certain amount of control over the insertion torque.

Insertion by machine

Machine insertion requires a surgical treatment unit, the torque of which can be controlled, or at least a low-rpm dual green handpiece. Accurate setting of the torque and the number of rotations is required. The rotation rate should not exceed a maximum of 30 rpm^{-1} may not be exceeded. The torque must be restricted to the maximum load limit of the screw.

Machine insertion enable to achieve a consistent torque during incorporation, but also means that the operator loses the feeling for the bone. During manual insertion, it is possible to perceive the interaction between the screw and the bone by tactile senses.

Attaching the orthodontic linking elements

Load may be placed on the miniscrew immediately after insertion. No healing phase is required. The selected linking element must be prepared accordingly and attached to the head of the screw (Fig. 2.12). To avoid damage to the teeth to be moved, the load on the linking element should be between 0.5 and 2 N (about 50 and 200 g).

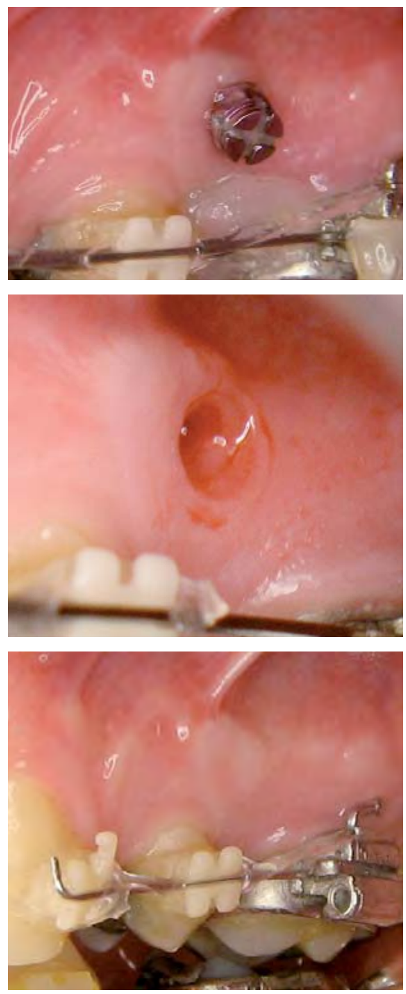
Basic aftercare (postoperative)

The healing of the gingival tissue and hygiene status after insertion must be regularly reviewed during the entire time that the miniscrew remains in place. It must be pointed out to the patient that any manipulation of the screw head with the fingers, tongue, lips and/or cheeks should be avoided, otherwise the screw may be prematurely lost.

Removing the miniscrew

A miniscrew can be removed under local anaesthetic. First the linking elements must be removed, after which the miniscrew may be removed with the same tools used for insertion. The resulting wound requires no special care and usually heals within a short time.

Fig. 2.12: Linking of the miniscrew to the orthodontic apparatus.

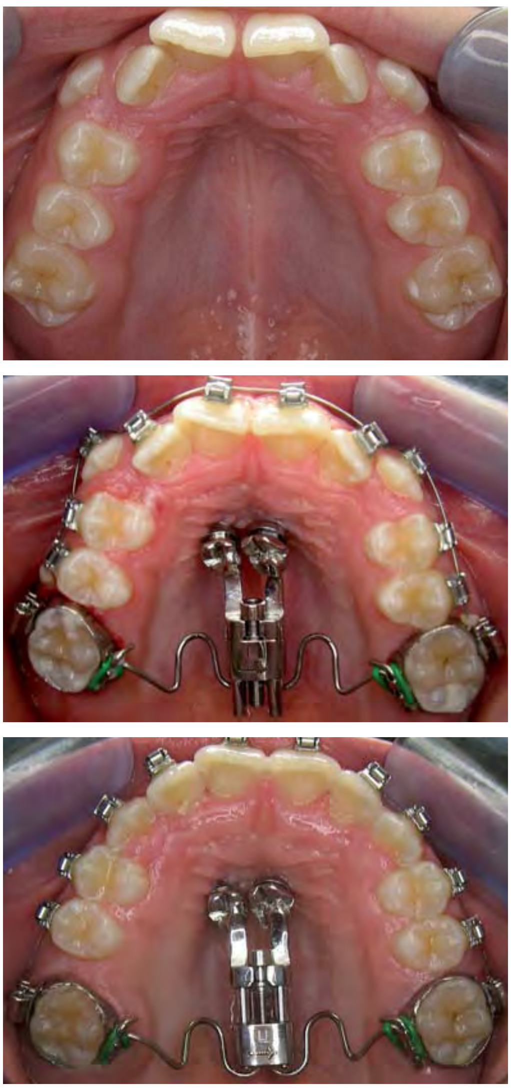


Figs. 2.13a–c: Miniscrew after removal and after a 4-week healing period.

Part III: Clinical examples (1)

Horizontal tooth displacement

Lack of space is one of the main reasons for oblique positioning of teeth. One way to solve this problem is to create the necessary space. On the other hand, however, premature loss of teeth or anatomical abnormalities may mean that gaps are present that require modification for various reasons. For the correction of horizontal tooth displacement, miniscrews can be used as these produce no undesirable reactive effects.



Figs. 3.1a–c: Distalisation of the upper molars. **a):** Mesial positioning of teeth 16 and 26 showing clear displacement of the canines. **b):** Walde frog appliance (FORESTADENT) anchored to two miniscrews. **c):** Distalisation by approx. 6 mm after 3 months treatment providing sufficient space for the correct repositioning of the canines.

Distalisation

The first case (Fig. 3.1) involved a frequently encountered problem. The patient's molars had migrated in a mesial direction. This resulted in a marked loss of space in the region of the canines. The two treatment options in such cases are extraction or distalisation. In presented case, distalisation was a viable option and extraction was unnecessary. All conventional techniques for distalisation (apart from the use of headgear) require support from other groups of teeth. Creating anchorage in this way results in negative, undesirable reactive effects. In the example under consideration, protrusion of the anterior teeth could have been the result, and there is a high probability that this would have occurred if one of the conventional methods for distalisation had been employed. Such problems can be avoided by the use of miniscrews.

Miniscrews can be inserted in the vestibular and—as in this example—palatinal areas. Vestibular insertion of a miniscrew (e.g. between the premolars) is always associated with the problem that, after a certain point of time, the miniscrew will eventually be in the way of tooth migration. When this occurs, the miniscrew must be extracted and a conventional form of anchorage/blocking (e.g. a ligature) must then be used. In the case we are considering, the presence of the primary molars also represented a contraindication for insertion on the vestibular side of the premolar region. The paramedian insertion of two miniscrews has several advantages. Firstly, they provide a very solid basis for anchorage of the distalisation appliance. Secondly, the miniscrews will never impede the movement of the lateral teeth. Even after successful molar distalisation, they can be used to stabilise the situation achieved for the remainder of the treatment. Thirdly, there is no risk of damaging other teeth because of an unfavourable spatial situation and/or incorrect insertion. One disadvantage of the coupling necessary between the frog appliance used (FORESTADENT) and the miniscrews (see Fig. 3.1) is that cleaning becomes difficult.

Figs. 3.2a–d: Distalisation of the upper laterals. **a):** Miniscrews were inserted in the paramedian region (OrthoEasy®, FORESTADENT) **b):** OrthoEasy® with attached laboratory abutments. **c):** The frog appliance was lashed to the laboratory abutments. **d):** Lateral X-ray showing the ideal positioning of miniscrews, laboratory abutments and frog appliance.

The fact that large areas of the mucous membrane are covered means that there is the risk of development of perimucositis. If this exacerbates to become periimplantitis, premature loss of the miniscrews could be the result. A possible future alternative could be the use of so-called laboratory abutments (Fig. 3.2), which contain no plastics and can be used to couple the appliance with the miniscrews in a completely hygiene-friendly way.

Mesialisation

One of the most problematic areas of orthodontic therapy is the correction of the anterior displacement of teeth and particularly of jaw segments. It can often seem that the availability of miniscrews now means that conventional appliances no longer need to be used at all. However, depending on the baseline situation and the nature of the required correction, the use of a combination of devices and appliances can be recommended. This is often advisable and may even be necessary for biomechanical reasons, as in a class III situation, for example. In the case shown in Fig. 3.3, forced transverse expansion of the palatine suture was used in combination with mesial traction applied by means of a Delaire facial mask. The support provided by two miniscrews inserted in the paramedian region redirected the forces of sagittal and transverse movements almost entirely onto the bones. Dental side effects were markedly reduced.

Space closure

Thanks to the availability of miniscrews, new therapeutic techniques can now be used particularly for the management of the partially endentulous situation that obviate the need for compensatory extractions and the problem of loss of stability of the units used for anchorage support. It is here that the effect of Newton's third law is particularly apparent, and the interception of the opposing forces is a major consideration within the therapeutic strategy. The orthopaedic closure of dental spaces using miniscrews can be highly recommended if:

- there are no alternative and viable conventional methods and/or there is insufficient certainty that these will be effective
- the extensive use of braces is to be avoided for cosmetic or functional reasons
- a short-term treatment or partial treatment is required that does not involve correction and realignment of the basic dental arch
- asymmetrical treatments are associated with the risk of midline displacement and the possibility of compensatory extraction
- a suitable dental baseline situation is to be created for preprosthetic treatments.

Important: Where space closure treatment is proposed, it must be ensured that the patient is not only aware of the costs and risks of the treatment but also of the available alternative options, such as the use of a bridge or implants.

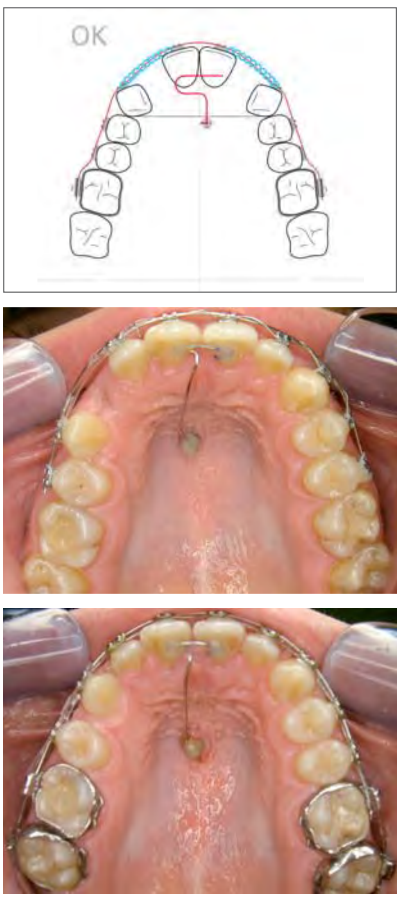
There are three types of space closure:
a) anterior space closure (e.g. in displacement of the lateral incisors)
b) En masse retraction or canine retraction (e.g. where the premolars are missing)

Figs. 3.3a–c: Mesialisation of the upper molars. **a):** Miniscrews inserted in the paramedian region with laboratory abutments (FORESTADENT) and transverse screw with hook for a Delaire facial mask. **b):** Status after transverse expansion and formation of a median diastema. **c):** Extraoral view of the appliance with Delaire mask.

c) space closure in the molar region (e.g. to avoid the need for prosthetic measures).

a) Anterior space closure

Orthopaedic space closure is frequently indicated if there is a gap in the anterior row of teeth, particularly in the region of the lateral incisors. Undesirable effects of conventional therapeutic techniques are the displacement of the midline and/or negative inclination of the anterior teeth. If miniscrews are used for the stabilisation of the median incisors (Fig. 3.4), these problems can be avoided. A stable, rigid steel arch with a size of at least 0.48 mm x 0.64 mm (19 x 25) attached to two miniscrews inserted in the median or paramedian region can be used to stabilise the anterior teeth. Using the standard vestibular mechanical techniques, the gap can be closed without altering the position of the incisors.



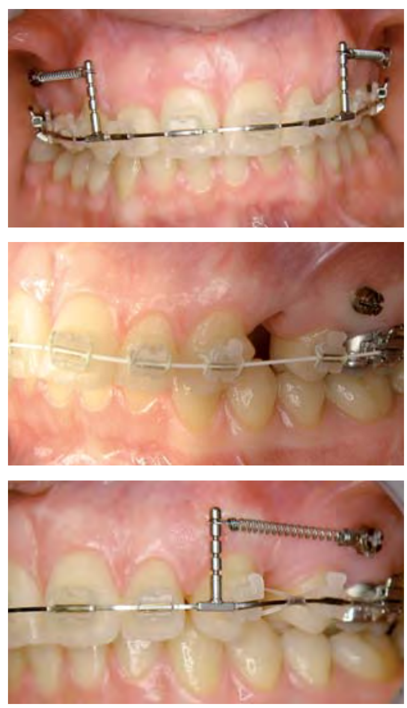
Figs. 3.4a–c: Space closure in the region of the upper anterior teeth. **a):** Diagram showing the anchorage principle. **b):** Baseline situation: the central frontal teeth were held in place using a steel arch (19 x 25) fixed to a miniscrew with additional frontal dental torque **c):** Outcome after 9 months: the anchorage is stable.

b) En masse or canine retraction

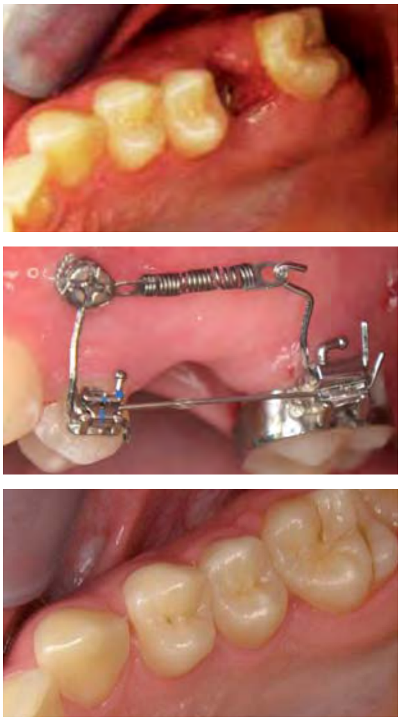
Miniscrews can also be used as an aid in this form of treatment (Fig. 3.5). In contrast with the conventional appliances, there is not only no loss of anchorage but also a biomechanical benefit in terms of more favourable direction of forces. If the miniscrew and the fitting for the active element (traction spring or elastic chain) are positioned at the same level as the resistance centre of the canines, physical movement of the tooth (or teeth) is possible.

c) Molar space closure

Premature loss of the primary molars has not yet been eradicated despite all the advances made in prophylactic treatments. There can be a need for appropriate therapy, particularly in cases where the adjacent teeth are not carious (Fig. 3.6). What should the patient be offered—implants, bridge or space closure treatment? With a view to minimize effects on the existing materials, the realistic long-term prognosis for the anchorage teeth and conservation of the surviving natural teeth, a prosthetic solution would not appear to be appropriate. The basic concept of restorative dentistry—first destroy in order to reconstruct—is frequently not the correct solution. Let us assume that the strategy adopted is to mesialise tooth 27 in order to compensate—using a natural method—for the loss. The skeletal anchorage means that undesirable side effects, such as reciprocal space closure, are avoided. Only a few elements (brackets, springs etc.) are needed to support the mesial movement. The treatment remains invisible to the casual observer while, in comparison with the stated alternatives, it is very cost-effective and provides for a high level of conservation of the natural elements. The prog-



Figs. 3.5a–c: Space closure in the region of the upper anterior teeth. **a):** En masse retraction with the aid of miniscrews and a Power Arm (FORESTADENT), which has been "crimped" here. **b):** Status after extraction of the premolars, miniscrew (OrthoEasy®). **c):** The Power Arm is used as a sliding mechanism in order to further distalise the canine.



Figs. 3.6a–c: Space closure in the region of the upper laterals. **a):** Baseline situation: teeth 25 and 27 are free of caries. **b):** Using miniscrews (OrthoEasy®, FORESTADENT), it is possible to provide "invisible" treatment. **c):** Very few elements are required for mesialisation.

nosis for the long-term preservation of the natural teeth is very good.

Vertical tooth displacement

Any displacement of teeth along the vertical axis can represent a cosmetic and/or functional problem. The solution is extrusion or intrusion with the help of skeletal anchorage. This technique can be very simple to implement as well as being very cost-effective.

Extrusion

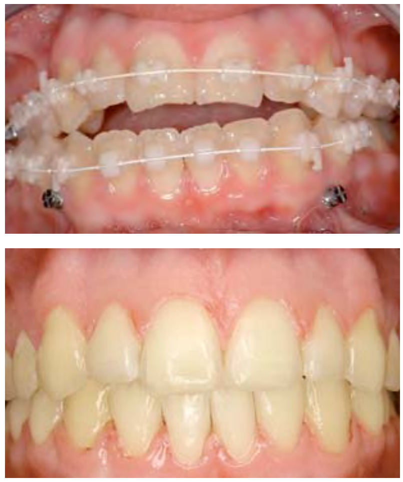
Extrusion with the help of miniscrews may not only be used for single teeth (Fig. 3.7), but also for groups of teeth (Fig. 3.8). Trauma had caused the intrusion of tooth 22 (Fig. 3.7) and the tooth was returned to its original position within 3 months by means of indirect anchorage of tooth 23 to a miniscrew using a straight wire appliance. In the case of a bite that exposed tongue and bone (Fig. 3.8), the approach adopted was to provide transverse expansion and extrusion of the anterior teeth. Intermaxillary rubber traction braces connected to miniscrews in the lower jaw were used. If the braces had been connected to the lower anterior teeth, undesirable extrusion of these would have been the result (every action has an equal and opposite reaction). Because of the small root surface, this process would have occurred in a much shorter space of time than in the case of the upper anterior teeth. The opposing bone in the lower jaw prevented this undesirable reactive effect.

Intrusion

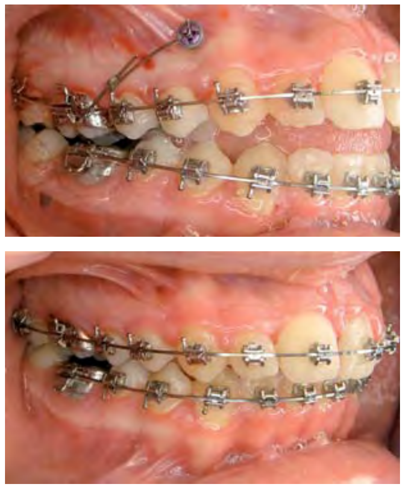
This open bite with extrusion of the tongue (Fig. 3.9) was treated by means of intrusion of the molars and consequent caudal rotation of the maxilla. Miniscrews were inserted in the first and second quadrants in each case between the canine and the first premolar. A Titanol® uprighting spring (FORESTADENT) was attached to the capstan of the miniscrew and the screw was set to intrusion. There was even some overcorrection of the positioning of the first molars on both sides after 5 months intrusion, resulting in closure of the frontal bite.

Conclusions

It may be necessary for some therapists to overcome logistical and emotional barriers before they can begin to employ miniscrews. But it is only when they are used that it becomes apparent how versatile they can be. Miniscrews make our routine work that much simpler. They enhance the efficiency and effectiveness of many dental appliances. There is an overall improvement in treatment quality.



Figs. 3.8a, b: Extrusion in order to close an open bite caused by tongue thrust with deterioration of the upper jaw. **a):** The aim was to extrude the upper frontals over the miniscrew in the lower jaw. **b):** Status after 12 months.



Figs. 3.9a, b: Intrusion in order to close a tongue and skeletal open bite. **a):** Intrusion of the molars was effected using a Titanol® uprighting spring (FORESTADENT) **b):** Status after 6 months.

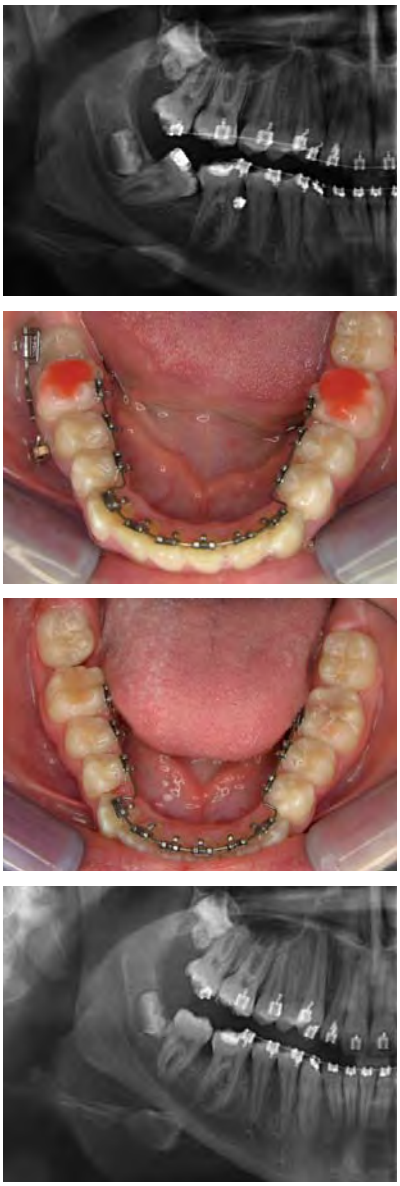
Figs. 3.7a–c: Extrusion of a single tooth. **a):** Viable lateral incisor following intrusion due to trauma. **b):** Miniscrew with indirect anchoring of the canine and straight arch technique in order to extrude 22. **c):** Status after 3 months.

Part IV: Clinical examples (2)

Repositioning individual teeth

The uprighting of molars

The straightening of mesially tipped (second) molars in a full dentition represents a therapeutic challenge. The treatment is further complicated if the tooth is not only tipped but also partly impacted. The presence of a non-erupted third molar does not simplify the producers (Fig. 4.1a). When planning the required appliance, it is important to consider whether it is necessary, for example, to reshape the entire dental arch (Fig. 4.1) or just upright the tipped tooth. If miniscrews with bracket heads are used it is possible to employ a special NiTi uprighting spring (e.g. Memory Titanol® spring by FORESTADENT). A standard multibracket appliance can be used to reshape the dental arch. At the same time, a second force element can be applied with the aid of a miniscrew and an uprighting spring (Figs. 4.1b–d). This avoids the loss of anchorage that inevitably occurs when an uprighting spring is fixed to the multibracket appliance only (Fig. 4.2). The straightening of an individual tooth may become necessary for periodontological, prosthetic or orthodontic reasons. This is a very simple procedure if a miniscrew and uprighting spring are used, and the appliance remains invisible to the observer. The tooth need only be fitted with an appropriate attachment system that makes it possible to fix this to the uprighting spring. Depending on how the spring is set, it is even possible to achieve intrusion or extrusion of the tooth. This form of treatment is inexpensive for the patient, yet the orthodontist will also find it highly effective.

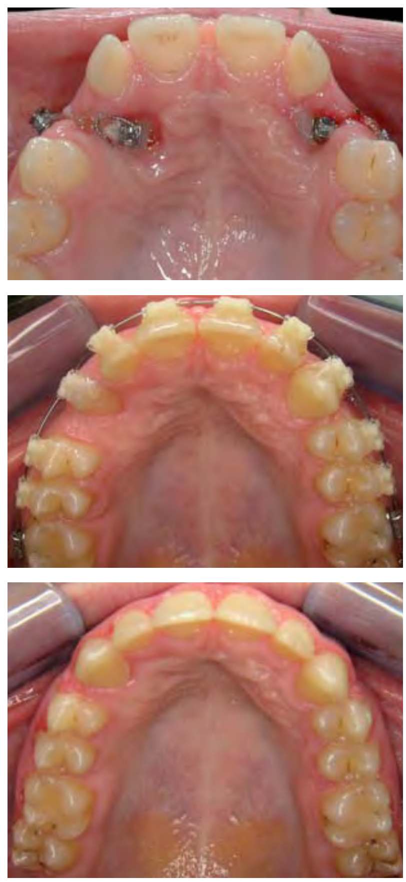


Figs. 4.1a–d: The uprighting of a second molar with simultaneous reshaping of the dental arch. The problem is clearly visible in the X-ray. The uprighting spring is fixed to a miniscrew **(a, b)**. Status after 5 months without reactivation of the arch section **(c, d)**.

Fig. 4.2: The uprighting spring fixed to the main arch not only effects the molars, but also causes displacement of the premolars (loss of anchorage). *(Photo: Prof. Dominguez, São Paulo)*

Alignment of retinated teeth

The alignment of retained or displaced teeth, particularly in the case of canines, is one of the most common forms of a surgical intervention in the field of orthodontic techniques. Numerous appliances are available—rubber bands, springs, orthodontic chains etc.—that are effective to a greater or lesser extent. All these mechanisms have the same underlying problem. The neighbouring teeth must be used—directly or indirectly—to provide an anchorage so that the required traction forces can be applied. Ideally, this component will offer the greater resistance so that only the retained tooth moves. Realistically, however, both components tend to move towards each other. In the worst case scenario, only the group providing anchorage is displaced from its original position. This can occur if there is ankylosis of the retinated tooth, something which is difficult to evaluate during initial ex-



Figs. 4.3a–c: The alignment of a displaced canine using a miniscrew. After the canines have been exposed, these are attached to a bracket by means of a miniscrew **(a)**. After removal of the screw, the dental arch can be reshaped using a conventional technique **(b, c)**.


Figs. 4a–e: Obtaining additional transverse space by means of 'hybrid RPE'. The initial diagnosis is an asymmetrical narrow jaw with insufficient space for tooth 13 **(a)**. After fixture of the brackets, two miniscrews (OrthoEasy®) were inserted during the same session **(b)**. The hybrid RPE appliance was attached using laboratory abutments (FORESTADENT) to the miniscrews and molar bands **(c)**. The diastema shows the effect of the appliance after 10 days' use **(d)**. Status after transverse expansion and concurrent reshaping of the dental arch **(e)**.

amination . If the attempt is made to move an ankylosed canine towards insufficient dental anchorage, the result will be the worst case scenario. This can lead to an open bite in the region of the anterior teeth and premolars.

Miniscrews provide the definitive form of anchorage for the alignment of displaced teeth (Fig. 4.3). If sufficient space is available, brackets will not be needed in the initial phase of treatment.

Skeletal adjustments

Palatine suture expansion

Rapid palatal expansion (RPE) is one of the most effective and stable methods of acquiring more transverse space in the upper jaw. The targeted screw rate should be in the range 0.2–0.6 mm/day. As a rule, the appliance is fixed by means of bands to the molars and premolars. The desired transverse width can generally be achieved within 10–20 days. Thereafter, a 3-month stabilisation phase should be observed to allow ossification of the ruptured palatine suture.

The standard anchorage technique—with dental support only—has several disadvantages. The most significant is the risk of tipping the anchor teeth. Many appliances have been described which distribute the force over more than one tooth. A further problem is apparent here. As it is necessary to leave the appliance in place for a longer period after the active phase, it is only possible to commence further corrective treatment for teeth in the anterior region. It is possible to overcome these problems by using the so-called hybrid RPE (Figs. 4.4–4.6). Bands are employed as usual in the molar region. In the anterior region, the PSE appliance is fixed using two miniscrews. These should be placed on a notional transverse line connecting the canine/premolar contact points paramedially. Distraction is achieved using the same method as in standard techniques. There are several advantages to hybrid RPE. Preparation of the apparatus is much simpler and cheaper, while the dental arch, including the premolars, is accessible for additional tooth correction measures.

Fig. 4.5: 'Hybrid RPE' appliance with adjuvant anterior hooks for the attachment of a Delaire mask.

Class II corrections

In the case of patients with class II malocclusion who have completed or are near completing their growth phase, simple techniques for the forward positioning of the lower jaw are usually ineffective. Following a thorough initial examination and diagnosis, there are three possible therapeutic approaches: 'camouflage', fixed class II correctional appliances (Herbst® splint, Sabbagh Universal Spring, FMA, Jasper Jumper etc.) or orthognatic surgery. The patient must be informed of the advantages and disadvantages of each approach.

All fixed class II correctional appliances—irrespective of whether these use the Herbst splint or canted plane principle—have the same problem and the same undesirable side effects. There is a risk of protrusion of the lower frontal teeth and/or distalisation of the upper molars. By means of passive stabilisation with the aid of two miniscrews (Figs. 4.7, 4.8), these effects can be readily avoided.

Figs. 4.6a–d: Bilateral cross-bite in a 7-year-old boy **(a)**. X-ray of the hybrid RPE appliance in situ **(b)**. Status after 10 days' use: cross-bite has disappeared and vertical bite has remained stable **(c, d)**.

Figs. 4.7a–c: Anchorage of the canine using a miniscrew avoids protrusion of the anterior teeth when using of a fixed class II correction appliance (here: Williams appliance, FORESTADENT).

Figs. 4.8a, b: The miniscrew stabilises the position of the molars to which the Kinzinger FMA is attached. This counteracts any protrusion of the premolars and anterior teeth **(a)**. Class I dental status on completion of treatment **(b)**.

Orthognatic surgery

After surgical intervention to relocate or reposition the jaw (for orthodontic or traumatological reasons), it is important to maintain a stable correlation between bone fragments and jaw in the postoperative phase. This promotes healing and prevents relapse. The occlusion appliance is fixed intraorally using intermaxilliary elastic or wire ligatures, depending on the situation. It is essential to use the appropriate fixing options, whether this is a splint (Schuchardt splint) or a multi-bracket appliance. Where these are really only needed in one jaw or jaw section, the question arises of whether, in the era of the miniscrew, it is necessary to involve the other jaw in the stabilisation of the surgical effect. If miniscrews are used in the opposing jaw (Fig. 4.9), the same effect is achieved—but with considerably less restriction from the point of view of the patient.

Fig. 4.9: The use of miniscrews to attach intermaxillary rubber traction bands means that no other attachments on the teeth are necessary.

Preprosthetics

It is the aim of preprosthetic orthodontics to position the teeth optimally for the subsequent prosthesis. This can include intrusion, uprighting, opening or closing of gaps, amongst other techniques. As this series and many other publications have already shown, miniscrews are particularly useful in this context. Miniscrews can also be used as anchoring elements for a provisional prosthesis. Where teeth are missing (particularly the second canines, Fig. 4.10a) and the growth phase is not yet completed, the fitting of an intermediate prosthesis is problematic. As an alternative, particularly where additional anchorage is required, miniscrews can be used. A longer screw (8 or 10 mm) can be inserted in the centre of the dental ridge (Fig. 4.10b). There should be at least 1 mm bone to the mesial and distal side of the miniscrew. The hole for insertion of a miniscrew (1.6 mm) should thus be at least 2.6 mm. A provisional crown can then be mounted onto the head of the miniscrew. If necessary, a bracket can be fixed to this crown (Fig. 4.10c).

Outlook

The clinical use of miniscrews supports a wide range of tasks. Dental repositioning that was previously deemed 'impossible' becomes achievable, while 'possible' repositioning techniques are improved and supported. In order to achieve this, miniscrews alone are not sufficient; an appropriate range of equipment is also necessary. Some suppliers of miniscrews are able to offer, in addition to screws and insertion tools, a number of devices that facilitate the use of miniscrews. The fifth part of this series will focus on the wide range of very useful auxiliaries that are available.

Figs. 4.10a–c: Missing tooth 12 is to be replaced by an implant-based crown. The initial phase of treatment involves widening the gap **(a)**. The head of the vertically inserted OrthoEasy® screw **(b)** is used to anchor a provisional crown (including bracket) which serves to widen the gap further **(c)**.

Part V: Therapeutic auxiliary elements

Down in the jungle

The number of dental businesses that offer miniscrews is constantly expanding. There are currently an estimated 45-plus worldwide. Two trends are apparent from the range of products that are currently available. There are companies that offer miniscrews only together with the required insertion instruments. However, miniscrews are only a means to an end where bone anchorage is concerned—an aspect that is far too often overlooked. This is because, if the desired therapeutic outcome is to be achieved, appropriate auxiliary devices must also be used (e.g. springs, elastic chains, wires, etc.). For the purposes of a treatment, this means that a range of different suppliers must be approached in order to obtain all the elements required for the actual procedure. There is the potential problem under these circumstances that the miniscrews and the auxiliary elements may turn out to be incompatible.

Companies supplying auxiliaries	Name of the miniscrew
DENTAURUM (Germany)	tomas®-pin
FORESTADENT (Germany)	OrthoEasy®
Mondeal (Germany)	BENEFIT
HDC (Italy)	Spider Pin
Micerium (Italy)	M.A.S.
Bio Materiales (Korea)	Orthodontic Mini Implant
Dentos (Korea)	AbsoAnchor
Jeil Medical (Korea)	Dual-Top™ Anchor Screw
Bio-Ray (Taiwan)	A-1
IMTEC Corp. (USA)	Ortho Implant
Ormco (USA)	VectorTAS™

Table 5.1: There are at least 45 companies which manufacture or supply miniscrews. However, only 11 of these offer auxiliary elements for use in maxillary orthopaedic treatments that are compatible with their own screws.

There are very few suppliers of miniscrews who also offer a more or less complete system. This refers to a range which includes, in addition to miniscrews, diagnostic and therapeutic auxiliary products (Table 5.1). Where this is the case, it can be assumed that the head of the miniscrew will be compatible with the auxiliary elements. The building block principle can be used to construct an individually-tailored appliance from the various elements. The greater the range of auxiliary elements that is available, the more freedom and flexibility they afford in a range of applications.

Suppliers of miniscrews whose core business is the dentofacial orthopaedic sector usually also offer the necessary auxiliary products in their range. It is both convenient and saves time for the user when the appropriate articles are offered together, or are even available in the form of sets.

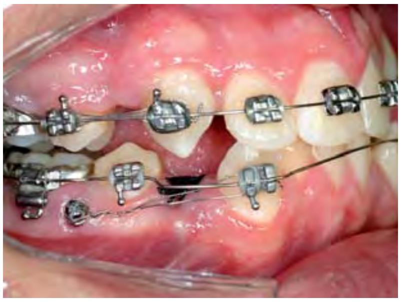
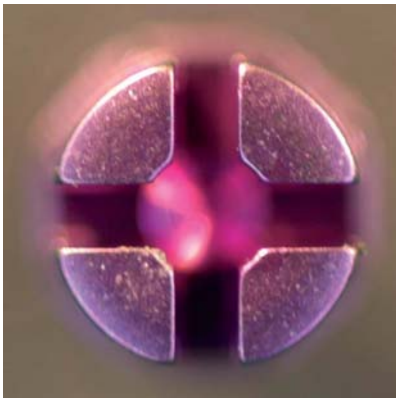


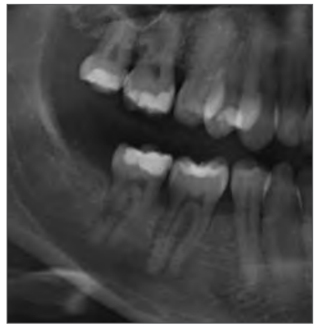
Fig. 5.1: The wire ligature is appropriately activated and applies the required force for repositioning of the canine. *(Photo: Dr. Morea, São Paulo)*

Fig. 5.2: The use of a square profile wire makes it possible to achieve very rigid (indirect) attachment. *(Photo: Dr. Böhm, Obertshausen)*



Figs. 5.3a–c: When a wire is to be bent at right angles in the screw slot **(a)**, the edges at the point of crossover must be removed. This convenient detail is currently only found in the FORESTADENT OrthoEasy® **(b)** and the tomas® pin from DENTAURUM **(c)**.


Figs. 5.4a, b: Uprighting and space closure of a tipped molar by using an uprighting spring. Clinical situation **(a)** and X-ray **(b)**.

Figs. 5.5a, b: Situation after 13 months of uprighting and space closure, clinical situation **(a)** and X-ray **(b)**.

Auxiliary elements for direct chairside use

These auxiliary elements can be divided into three main groups:

- Basic elements
- Semi-finished elements
- Finished elements.

Classification is determined by the extent to which the user has to process or manipulate the article before it can be used.

Basic elements

These consist solely of orthodontic wires (with round profiles and particularly wires with square profiles) in various grades and of various materials. The wires are used to fashion individual auxiliary elements, and this can be more or less time-consuming depending on the type of appliance required. The wires (particularly those made of stainless steel) are quite reasonably priced. Round profile wires are mainly used as ligatures, in other words, simply as fixing elements, but if appropriately twisted, they can also be used for traction purposes (Fig. 5.1). Three-dimensional monitoring of round profile wires is not possible as they offer little resistance to torque. Square profile wires, on the other hand, can be subjected to 3-D inspection because they are torsion-free, highly stable and provide (depending on their dimensions) for a very rigid attachment between miniscrew and appliance (Fig. 5.2). It is advisable to use a grade of wire that fills the slot of the miniscrew.
In some cases, it may be necessary to bend a square profile wire. This can be advantageous in mesialisation when a hook can be provided on the pin for attaching a spring or elastic chain and also for attachment to the main arch of the appliance. For this purpose, the wire should be bent at a right angle. Bent wires can also be used in one further situation. A ligature or a drop of adhesive is used to fix a square profile wire in a miniscrew slot. Depending on the reciprocal forces and the quality of fixation, the wire (square or round profile) can start to slip within the slot. This can readily be prevented by bending the wire, at least if a pin with a cross slot is used (Fig. 5.3a). In these two situations, however, a grade of wire that fills the slot can only be used if the edges of the slot at the point of crossover are removed. Of the 16 miniscrews with cross slot bracket heads currently available, this convenient detail is only found in the FORESTADENT OrthoEasy® (Fig. 5.3b) and the tomas® pin from DENTAURUM (Fig. 5.3c).

Fig. 5.6: A round profile wire attached to a crimpable tube can be used to prepare individual hooks (for example for use in en masse retraction).

Semi-finished elements

These auxiliary elements are generally components that are supplied in a functional form, but must be adapted to individual requirements (Table 5.2). Depending on the type and material of the product, prices are in the moderate range and the time required for preparation is minimal. One example is the uprighting spring (Fig. 5.4a), which can be used after only a few adjustments. Depending on how the spring is set, lower molars can be straightened and concomitantly intruded or extruded. This auxiliary product is particularly useful in preprosthetic procedures in which teeth need to be moved to provide an optimal baseline (Fig. 5.4b). Crimpable tubes to which square profile wire has been welded (Fig. 5.5) can be used to attach miniscrews to a pre-existing MB (multibracket) appliance. If a fixed anchorage becomes necessary during treatment, this can be easily implemented using these wire elements without having to remove the appliance or parts of it. During en masse retraction, crimpable tubes with attached wire can be used to fashion individual hooks (Fig. 5.6). These can thus be used to ensure that the traction force (provided by spring or elastic chain) is applied near the centre of resistance.
There are three companies that offer pre-prepared wire elements, such as the L and U wires (FORESTADENT) or the tomas® T wire (DENTAURUM). These elements facilitate the attachment of bands and brackets (Fig. 5.7a).
The tomas® T wire (Fig. 5.7b), with its three arms, provides for a wide range of possible application combinations. For the purposes of mesialisation, for example, one arm can be bent to form a hook. Another can be attached to the main arch by means of a cross tube.

Figs. 5.7a–c: Using the L-anchor (FORESTADENT), it is possible to rapidly attach a miniscrew to a bracket or band **(a)**. With its three arms **(b)**, the tomas® T wire (DENTAURUM), can be used to create a wide range of different attachments between a screw, an MB appliance or the teeth **(c)**.

Another variant devised by Dr. S. Baumgärtel is the fixation of the anterior teeth to a paramedian miniscrew (Fig. 5.7c).

Finished elements

This group covers a whole range of auxiliary products for use in many different applications (Table 5.3). All of these require little or no time for preparation and can be used directly without adaptive adjustments. However, these products are also accordingly priced relative to type and grade of finish.

Crimpable hooks

For the purposes of en masse retraction, it is often an advantage when the force provided by spring or elastic chain is applied at the same level as the centre of resistance. This can be readily implemented using ready-made hooks. These are crimped to the arch of the appliance (Fig. 5.8).

Compression springs

Compression springs also belong in the group of ready-made elements. They are sold by the metre. The springs can be used for distalisation and mesialisation. One problem is ensuring continuous activation as the spring effect is lost. Stop elements can be incorporated to avoid having to remove the whole appliance whenever this happens (see Table 5.3). These are available as crimpable elements and as screw stops. The latter have the advantage that they can be quickly adapted to a wide range of different situations. When such stops are used, the effort required for the repeated activation of springs is considerably reduced.

Coil spring elements

Coil springs are no innovation in the field of dentofacial orthopaedic treatment. However,

Semi-finished elements which need to be individually adjusted

Element	Device	Application	Characteristics	Product name	Available for	Example applications
	Power arm	"En masse"-retraction	Crimpable tubes with a welded-on wire for individual hook formation. They can be used in certain situations to attach the main arch or a segment to the pin.	tomas®-power arm square tomas®-power arm round Question Hook	tomas®-pin tomas®-pin A-1	
	Wire elements	Direct anchorage	Prebent/ready-to-use wire elements for attaching pin head and the orthodontic appliance	tomas®-T wire L-anchor U-anchor Pin-Hook Abutment with wire 0.8 or 1,1 mm	tomas®-pin OrthoEasy® OrthoEasy® M.A.S. BENEFIT	
	Uprighting springs	For the uprighting of molars and, depending on setting, simultaneous intrusion or extrusion	NiTi spring, adjustably attached to a steel wire	tomas®-uprighting spring Titanol® uprighting spring	tomas®-pin OrthoEasy®	

Table 5.2

(Graphics: DENTAURUM, FORESTADENT; Layout: Oemus Media AG)

Finished elements which can be directly used

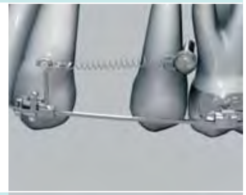
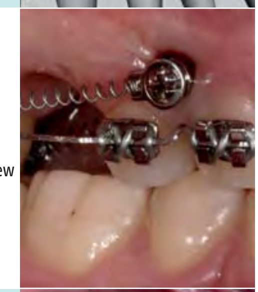
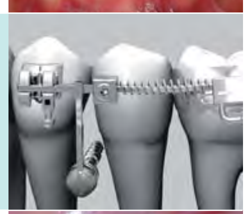
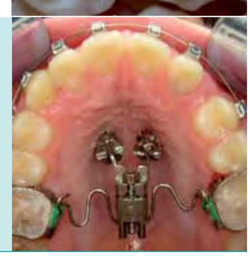
Element	Device	Application	Characteristics	Product name	Available for	Example applications
	Crimpable hook	"En masse"-retraction	Crimpable tube with welded-on hook for attachment of elastic elements (elastic chains, springs)	tomas®-crimp hook Power arm crimpable Discopender Crimpable hook Crimpable hook	tomas®-pin OrthoEasy® Orthodontic Mini Implant Dual-Top™ Anchor Screw AbsoAnchor	
	Compression springs	Distalisation, mesialisation	Superelastic NiTi compression springs	tomas®-compression spring Compression springs TruFlex™ Nickel Titanium Spring	tomas®-pin OrthoEasy® Spider Pin	
	Coil springs	Mesialisation, distalisation, "En masse"-retraction	Superelastic NiTi coil spring with an eyelet that fits the pin head	tomas®-coil spring tomas®-Nikodem spring Coil springs VectorTAS™ Delta Spring Ortho Locking Closed Coil Springs NiTi closed springs NiTi closed coil spring Gentle NiTi closed coil spring Coil spring	tomas®-pin tomas®-pin OrthoEasy® VectorTAS™ Ortho Implant Dual-Top™ Anchor Screw AbsoAnchor AbsoAnchor A-1	
	Hook for elastic chains or springs	Mesialisation, distalisation, "En masse"-retraction	Hook compatible with pin head. Provides for secure attachment of elastic chains and springs	tomas®-hook tomas®-monkey hook Monkey hook Screw hook	tomas®-pin tomas®-pin M.A.S. A-1	
	Sliding hook	Mesialisation, distalisation, "En masse"-retraction	Square tube with extension arm for attachment of elastic elements (elastic chains and springs)	Power arm sliding VectorTAS™ Powerarm Sliding hook	OrthoEasy® VectorTAS™ A-1	
	Stop elements	e.g. for activation of compression springs without removing the appliance	Tube with screws or open metal tube for attaching to appliance	tomas®-stop screw tomas®-slotted stops Crimpable stop Crimpable stop	tomas®-pin tomas®-pin OrthoEasy® AbsoAnchor	
	Cross tube	Indirect attachment	Cross tube for the connection of two wires	tomas®-cross tube cross tube	tomas®-pin OrthoEasy®	
	Abutments	Distalisation, palatine suture expansion (PSE)	Can be mounted on screw heads. They represent a crossover to laboratory-prepared appliances (e.g. for distalisation, PSE etc.)	Labor Abutment BENEFIT-Standard abutment BENEFIT-Abutment with Slot BENEFIT-Abutment with bracket BENEFIT-Abutment with wire BENEFIT-Connecting plate with fixating screw	OrthoEasy® BENEFIT BENEFIT BENEFIT BENEFIT BENEFIT	

Table 5.3

(Graphics: DENTAURUM, FORESTADENT; Layout: Oemus Media AG)

Fig. 5.8: Use of crimpable hooks (tomas® crimp hook, DENTAURUM) makes it possible to transfer the point at which force is applied to the level of the centre of resistance. The eyelet of the coil spring fits the miniscrew head exactly. *(Photo: Dr. Morea, São Paulo)*

springs is generally too small to be attached to miniscrews (Fig. 5.7b). A firm attachment to the head can only be achieved using ligatures or ready-made hooks that allow attachment of the spring to the head. For this reason, some suppliers now offer coil springs (Table 5.3) with at least one eyelet that is compatible with the head of their miniscrew (Fig. 5.8). These springs are generally made of NiTi and can be used in many different applications.

New on the market are the Nikodem springs (Fig. 5.9a). These flat coil springs made of NiTi were originally developed for the alignment of displaced canines. However, they have also since been found to be effective in intrusion and en masse retraction treatments (Fig. 5.9b).

Elastic chains are widely used traction elements. In contrast with NiTi springs, however, these rapidly lose their effectiveness. For this reason, a chain is only placed around the head of a miniscrew so that it can be more easily removed later. Depending on head design and the direction of the force applied, it is possible for the chain to become accidentally dislodged from the screw head. This problem can be avoided by the use of ready-made hooks (Table 5.3) that can be attached to the head of the screw.

Sliding hooks

Sliding hooks with a welded arm for attaching springs (Table 5.3) are an equally familiar piece of equipment. They are experiencing something of a renaissance in connection with the use of miniscrews. They are used for en masse retraction, mesialisation and distalisation. The effect of a sliding hook is determined by many different factors, which is why the value of attaching sliding hooks to the arch is disputed.

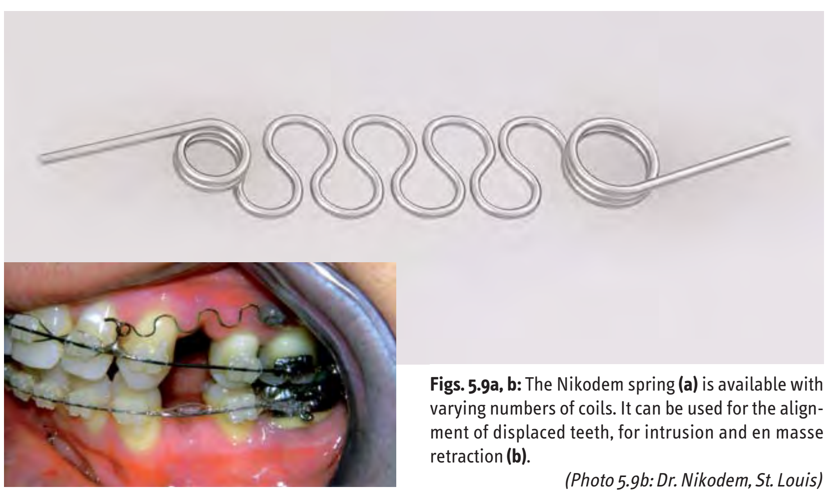
Auxiliary elements for laboratory use

All the elements discussed above can be prepared and inserted, with varying amounts of time expenditure, directly at the chairside. In recent years, the range of applications for miniscrews has also been extended to skeletal adjustment treatments, such as palatine suture expansion (see KN 4/2008). The corresponding appliances require very careful preparation, and for this reason, the related tasks have been transferred to the laboratory. The principal procedure involves the insertion of the miniscrew(s) and the subsequent reshaping process. Once a working model has been prepared, the appliance is constructed and adjusted as appropriate. For connection to a miniscrew, a suitable abutment must be employed. In hybrid PSE, for example, two arms of the expansion screw are welded to the abutment. The laboratory abutments available from FORESTADENT fit the head of the Ortho-Easy® screw. An adhesive is used for fixture after insertion.

An innovative approach is the BENEFIT screw and system (Mondeal). Analogous to prosthetic implants there is an implant placed in the bone. Instead of the previously known, firmly to the threaded part related head, there are different abutments (Table 5.3) available. These will be threaded to the bone screw. This way, many installations can be prepared in the laboratory for example, distalization, anchoring, retention RPE. This saves chair time. For many mechanisms, such as the molar uprighting or intrusion impression is not necessary and the BENEFIT implant can be directly used.

Summary

Depending on the task in hand, it will be necessary to use various auxiliary elements. Most of the connection elements discussed are not new and have already been used successfully in maxillary orthopaedic treatment for some time. For this reason, most of them will already be available in every practice, but often not where they should be. To avoid wasting time searching for tools, it is advisable from the point of view of efficiency to have the most important auxiliary elements to hand in a tray. One can make such a tray You can either create a DIY version or get hold of one of the ready-made boxes available on the market.



Figs. 5.9a, b: The Nikodem spring **(a)** is available with varying numbers of coils. It can be used for the alignment of displaced teeth, for intrusion and en masse retraction **(b)**. *(Photo 5.9b: Dr. Nikodem, St. Louis)*

Part VI: Complications and risks

Preliminary remarks

The use of miniscrews facilitates many aspects of maxillary orthopaedic treatments and in some cases actually makes such treatments possible. But miniscrew-based treatments, in common with all medical procedures, are not without their problems, complications and risks. It should be borne in mind that medical progress is only possible thanks to the pioneers and patients who are willing to enter uncharted regions. The major phase of miniscrew trials began in 2000. Today, the use of miniscrews is becoming increasingly established and consolidated, meaning that the potential and limitations of miniscrews are also ever more apparent.
A single problem or mistake during the planning and implementation of a miniscrew procedure can have various consequences and result in a number of complications. Often, a whole cascade of adverse events is triggered. At first glance, there is frequently no direct connection between the appearance and outcome of a problem and/or a complication and its cause. Obviously, there are still some areas that have not been researched in detail. But we are becoming increasingly aware of what works well, what lies in the grey area between success and failure and what is bound to fail (Table 6.1). Because of this, it is essential that the patient is informed of the potential risks and of the availability of alternative treatments. The main problem or most commonly occurring complication is the loss of a miniscrew.

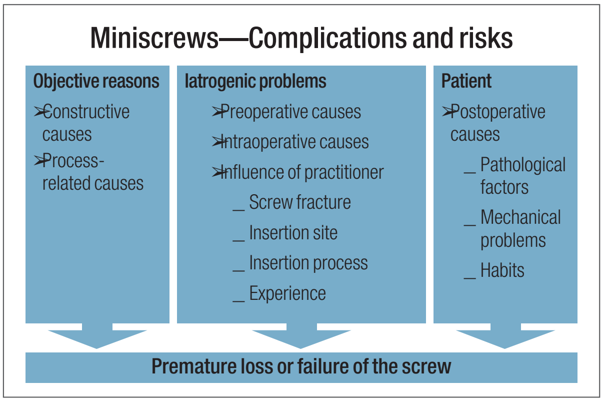


Fig. 6.1: There are many possible causes of the premature loss of miniscrews. The most common causes are practitioner-related.

Bone quality

Class D1	Almost entirely homogeneous compact bone
Class D2	Thick compact bone/closely knit spongiosa
Class D3	Thin compact bone/closely knit spongiosa
Class D4	Thin compact bone/loosely knit spongiosa

Fig. 6.2: Classification of bone quality per Misch (1990), Lekholm & Zarb (1985).

Success rate/failure rate

How low is the failure rate—or, to put it better, how high is the success rate of miniscrew procedures? It would be simple to reproduce the figures from published studies, but of what use is the following statement, for example: the success rate is in the range 0–100 %? The published results of clinical observation and 'studies' are all within this range. So, do we now know whether miniscrew XY is any good or not? And is this a suitable criterion in which to base the evaluation of a system or therapeutic approach?
A study conducted by Behrens & Wiechmann reported that failure rates of miniscrews inserted in the lingual lower jaw, for example, of 100 % for Dual-Top and 76.9 % for AbsoAnchor. What does this actually mean? Is AbsoAnchor better than Dual-Top? Here, cause and effect can be easily confused. One single region and a high rate of loss of two screws—surely this means that the insertion site was problematic or inappropriate. It seems probable that the outcome would be the same for all other miniscrews inserted at this location.
It should be borne in mind that it is unwise to draw premature conclusions from figures alone. There are many possible causes for the loss or partial failure of miniscrews. As a rule, it is not the system itself that is at fault! The comparability of clinical situations and experimental designs is a problematic area. Patients' reactions and their habits differ. The biomechanical concept can very greatly ... and so on. What is frequently not mentioned in published studies is the level of experience of the operating practitioner at the start of the study. This is also an important factor that determines outcome. In view of the numerous influencing factors, a direct comparison of different studies is simply not possible.
Statistics themselves are of little value because, in the end, it is individual experience that counts. There must be a willingness to learn, not only from one's own mistakes, but also from those of others. The success rate should be well above 90 %, although this is unlikely to be achieved by a practitioner when they first start using miniscrews. There is a clearly demonstrable learning curve in connection with this form of treatment, particularly with regard to the insertion procedure. The cause of most problems lies within the surgical procedure itself.

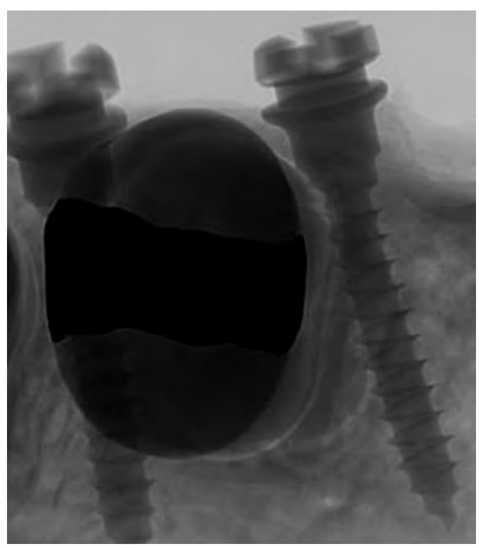
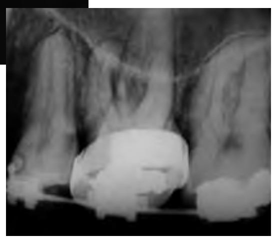


Fig. 6.3: The physiological movement of a tooth can, in some circumstances, cause micromovements of a screw, resulting in its failure.



Figs. 6.4a–b: If dental film is used, only the right-angle technique will supply useful information **(a)**. The use of an inappropriate radiological technique not only exposes the patient to unnecessary stress, but is worthless for treatment planning purposes **(b)**.

Iatrogenic problems

As Figure 6.1 and Table 6.1 show, there is a whole range of possible causes of the loss of a miniscrew. In view of their diversity, it will only be possible to consider a few aspects in the following discussion.

Planning and organisation

Carefully planning is undoubtedly one of the main keys to success. The same documentation and information required for other maxillary orthopaedic procedures are perfectly adequate when planning a miniscrew treatment. The choice of biomechanical concept for the approach should be based on medical history, assessment findings (including possible contraindications, see Overview 6.1), diagnosis and treatment aim. The general contraindications have been adopted from those that apply to implant procedures. The actual effect of these disorders and conditions on the use/outcome of miniscrew procedures has yet to be determined.

Overview 6.1

Local contraindications:

- **Quantitative and qualitative deficiency of bone at the insertion site**
- **Insertion**
  - in the mobile mucosa
  - on the lingual side of the lower jaw
  - near extraction wounds, dental follicles or deciduous teeth
- **Inadequate oral hygiene**
- **Recurrent disorders of the oral mucosa**
- **Osteomyelitis**
- **Radiotherapy of the cranial region**

General contraindications:

- **Compromised immune system**
- **Therapy with corticosteroids**
- **Blood coagulation disorders**
- **Uncontrolled endocrine disorders**
- **Rheumatic disorders**
- **Disorders of the skeletal system**
- **Hepatic cirrhosis**

Screw location

The best site for the screw should be selected on the basis of the biomechanical concept. The following should be borne in mind:

- There should be at least 0.5 mm bone around the screw on all sides
- The screw head should be positioned on inflammation-free, attached gingival.

It is most important to determine the quantity and quality of the bone at the selected site of insertion. This will provide initial indications of the quality to be expected (Fig. 6.2). However, an X-ray will only provide limited information in this respect, although it will make it possible to assess the spatial situation in two dimensions. This avoids or reduces the risk of damaging a root (Fig. 6.3). In the case of X-ray plates (particularly dental films), the direction of exposure, distortions arising from this and the possible loss of information must all be taken into account (Fig. 6.4). The spatial situation can also be assessed by reproducing the mucogingival line, the tooth axes and roots on a model (Fig. 6.5). Information on the maximum length of screw that can be used can be obtained by measuring the model along the insertion axis (Fig. 6.6a). This simple procedure helps avoid the risk of miniscrew perforation on the oral side (Figs. 6.6b and c). The required direction of teeth movement must also be accounted for during planning. This causes the resultant spatial situation to change during the course of treatment. A miniscrew must not interfere with or obstruct the desired movement (Fig. 6.7).

Insertion

The first question (taking into account possible complications) is, who should insert the screw? There is much in favour of this being done by the orthodontist. Studies have shown that orthodontists have a far better developed sensitivity in this regard. There is often failure—in other words, the loss of the miniscrew—if this is undertaken by 'experienced' implanters because these tend to ignore or be insufficiently aware of the requirements for the insertion of a miniscrew.

If the orthodontist is not to insert the miniscrew personally, a good line of communication with the surgeon must be maintained. Otherwise, there is a risk of problems of the sort problem illustrated in Fig. 6.7. Here, it is no longer possible to achieve the aim of treatment (mesialisation of the molars). Firstly, the screws are in the way. Because they are in the wrong location, the springs are too short and are ineffective. The correct position for the screws would have been between 3 and 4. This problem arose because of misunderstandings and a lack of communication between orthodontist and oral surgeon with regard to the aim of treatment and the positioning of the screws. The surgeon was unwilling to take risks and inserted the screws where there was plenty of space. Perfectly understandable from the surgeon's point of view, but in this case, it was a mistake—an iatrogenic error!

It is only possible to test the bone quality at the selected site immediately prior to insertion. In regions in which the bone quality is likely to be D3 or D4 (Fig. 6.2), a probe should be first inserted in the bone. If the probe penetrates deeply into the bone, the bone quality is not adequate for the insertion of a miniscrew. A different site should be selected.

Fig. 6.5: If the mucogingival line, the tooth axes and root contours are reproduced on the model, a good overview of the spatial situation can be obtained.

Checklist of the potential causes of the loss of miniscrews

There are many possible causes, but the probability of these occurring can differ greatly.

Table 6.1	Grade of probability				Source of information[1]			
	High	Medium	Low	Almost never	Study	Empirical	Analogy	Assumption
1. Objective causes **1.1. Structural causes** Dependent on system used and controllable by the practitioner only in the selection of system.								
Relation head/shaft length			ó					x
ø gingival neck > ø head			ó					x
Screw material		st. steel		Ti/Ti coating			x	
Relation of core diameter to thread diameter < 1:1.3 (slight undercut)		ó						x
Thread type (self-drilling = SD, self-cutting = SC)			ST	SD	x			
Incompatibility between pilot drill and miniscrew	ó				x			
1.2. Process-related causes								
Industrial sterilisation				ó				x
On-site sterilisation **with** disinfection				ó				x
On-site sterilisation: sterilisation only **without** prior sterilisation and cleaning			ó				x	
2. Iatrogenic problems These causes are exclusively the responsibility of the practitioner. **2.1. Preoperative causes** **2.1.1. Planning** Selection of the insertion site and the appliance								
Inappropriate biomechanical concept			ó					x
Site in lingual upper jaw	ó				x			
Site in retromolar lower jaw		ó				x		
Insufficient bone or space	óó					x		
Screw too long	ó					x		
Screw near deciduous tooth, dental folilicle or not yet ossified extraction wound	ó					x		
Screw head near mobile mucosa or band application site	ó					x		
Rotation of screw head in unscrew direction				ó		x		
Direct anchorage			ó					x
Gender				ó	x			
2.1.2. Preparation for insertion								
Contamination of screw and instruments, failure of hygiene procedure				ó				x
No disinfecting mouthwash used				ó				x
2.2. Intraoperative causes **2.2.1. Insertion site**								
Insufficient bone or space	óóó					x		
No primary stability	óóó					x		
Site in lingual upper jaw	óóó				x			
Site in retromolar lower jaw		ó				x		
Bone quality		óó				x		
Contact with root	óóó				x			
Screw near deciduous tooth, dental folilicle or not yet ossified extraction wound		óó				x		
Screw head near mobile mucosa or band application site	óóó					x		
Screw too long, perforation of contralateral side	óóó					x		

	Grade of probability				Source of information[1]			
	High	Medium	Low	Almost never	Study	Empirical	Analogy	Assumption
2.2.2. Insertion technique								
Insertion without prior perforation (with punch) of the gingiva			ó					x
Pilot drilling (ø of bore hole, technique, rate)	ó				x			
Tension in bone because of no pilot drilling			ó					x
Local overheating of bone due to lack of cooling or excessive torque effect				ó				x
Screw-in force (< 5 Ncm, > 10 Ncm)		ó			x			
Manual vs. mechanical insertion				ó				x
Overwinding of screw/slipping of screw in bone	óóó					x		
Insufficient 'feeling' for bone and screw			ó					x
Inadequate primary stability	óóó					x		
Contact with root		óó			x			
Practitioner's experience (learning curve)		óó				x		
2.2.3. Attachment to orthodontic appliance								
Inappropriate biomechanical concept			ó					x
Rotation of screw head in unscrew direction				ó		x		
Immediate or subsequent use			ó		x			
Persistent micromovements, e.g. due to direct attachment to elastic elements			ó					x
3. Patient/postoperative phase Many problems can be avoided if the medical history and findings are carefully documented and the patient is given adequate information. **3.1. Patient Status**								
Blood coagulation status			ó					x
Disturbance of wound healing or bone regeneration (e.g. in diabetes mellitus)			ó				x	
Tobacco and alcohol abuse			ó				x	
Immunosuppressive therapies (e.g. chemotherapy, radiotherapy)			ó				x	
Osteoporosis			ó				x	
3.2. Phase of therapy								
Immediate or subsequent use			ó		x			
Force vectors, inappropriate biomechanical concept			ó					x
Inadequate hygiene		ó				x		
Inflammation (peri-mucositis, peri-implantitis)	óóó				x			
Manipulation (habits, tongue play)		ó				x		
Gingival irritation		ó				x		

[1] Much of the information relating to the potential causes of miniscrew loss is not derived from studies but from the experiences reported by various authors. It must also be taken into account that miniscrews are implants. For that reason, it is very probable that a great deal of established information relating to the use of implants will also apply to miniscrews. But there are certain factors for which it can only be assumed that these might cause the failure of miniscrews—but there is no empirical evidence that this is correct.

The miniscrew must not be in contact with the tooth root. If this happens, the physiological movement of the tooth can cause persistent micromovements of the screw (Fig. 6.3). This impairs the healing process and means that secondary stability is not achieved. No periodontal complications will occur. Numerous histological examinations have demonstrated that there is complete healing of the periodontal ligament after the removal of a screw.

Some miniscrews have depth stops (Overview 6.2). It should become apparent if this touches the bone surface during insertion, providing the signal to stop screwing (Fig. 6.8c). However, depending on clinical factors, such as bone quality, site, angle of insertion and the insertion technique, the moment of contact is not generally detectable. There is thus the risk of overinsertion, and the destruction of bone structure by the screw thread. The effect is comparable to that of a corkscrew. The initial (or primary) stability of the screw appears to be good, but the screw is rapidly lost. In order to avoid this problem, it is advisable to measure the thickness of the gingiva prior to insertion. When this is considered in relation to the transgingival section, it is immediately apparent how far the miniscrew can be inserted in the bone.

The fracture of a miniscrew is a very rare occurrence. The following parameters (alone or in combination) determine the risk of fracture:

- Screw design: thin screws (Ø < 1.4 mm) and long screws (> 10 mm) tend to fracture more easily

- Anatomical factors
- thick cortical layer (> 2 mm) without perforation
- Insertion conditions—too much torque and/or inconsistent rate of insertion.

Many problems arise because of inadequate training or lack of experience. There may well be a higher rate of loss after the first 5–10 miniscrew treatments performed by an individual. The personal learning curve can be vastly improved by practising on porcine bone samples (Fig. 6.8). Various clinical situations can be simulated (bone quality, effect of drilling etc.). This training gives one the necessary 'feeling' for bone and screw.

In order to minimise potential risks, particularly during insertion, it is advisable to adopt a standardised procedure for routine use.

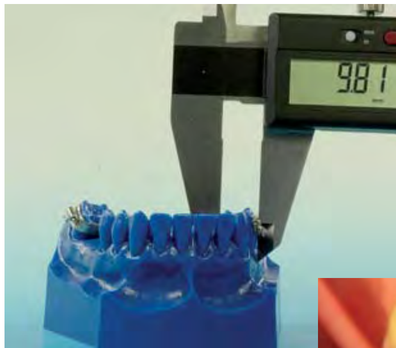
Stability—primary and secondary

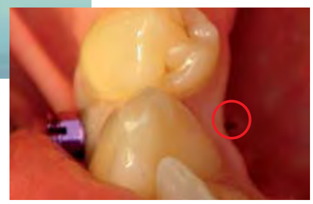
The primary stability of a miniscrew in the bone must be good. Screw stability is mainly determined by the cortical layer. The screw elements inserted within the spongiosa contribute little towards screw retention. The reasons for poor primary stability are:

- Inadequate bone material (quality/quantity)
- Overlarge bore hole due to wrong drilling technique (e.g. repeated insertion of the drill in the hole, deviation from required axis)
- Inappropriate screw thread (design of flanks and distance between them: relation of shaft to external diameter).

A miniscrew must have primary stability immediately on insertion, as it cannot be subsequently achieved. If this is not the case, it is best to remove the screw and select an alternative insertion site where the preconditions are better.

The regeneration of the bone tissue required to achieve secondary stability commences





Figs. 6.6a–c: Measurement of the model along the insertion axis **(a)** provides information on the length of screw that can be used and helps avoid the risk of perforation on the oral side **(b and c)**.

shortly after insertion (Fig. 6.9). If this process is persistently inhibited (e.g. by micromovements of the screw), the screw may be lost.

Force application

It is probable that the factor of whether a miniscrew is used immediately or later to apply force has no influence on the failure rate. Forces applied should be such that no damage is caused to the teeth to be moved. When a miniscrew is coupled to elastic chains or springs, this can result in micromovements of the screw. The distance between miniscrew and the site of application of force of any springs directly attached to it should be kept to a minimum. Otherwise, these will be ineffective (Fig. 6.7).

Postoperative complications

Inflammation

There is a high probability that a miniscrew will fail if peri-mucositis or peri-implantitis develop. It is thus important to ensure that the patient is appropriately informed (including instructions on oral hygiene) and that follow-up is possible. During follow-up, examination of the screw (status of the surrounding tissue, stability of the screw) should be carried out. The positioning of attached elements (springs, extension arms) may cause the development of pressure sores or even ulceration of the mucosa. This is something that should also be monitored and treated as necessary.

Oral hygiene

The patient must ensure that adequate hygiene is maintained in the area around the miniscrew. A normal toothbrush should be used for this purpose. There is evidence that electric toothbrushes, particularly those with rotating heads, can loosen miniscrews so that these fail. In addition to the cleaning technique itself, the frequency and intensity of cleaning are undoubtedly also important. Very frequent cleaning that results in persistent micromovement of the screw could well be disadvantageous.

Liability insurance

Orthodontists who wish to insert miniscrews themselves in their practices are frequently unsure about aspects of indemnity insurance. Policies available cover claims ranging from €1.5–5 million. When deciding on the extent of cover required (and thus the premiums that will need to be paid), the special circumstances of the practice need to be considered. An indemnity insurance policy will also cover the practice's personnel, but may exclude temporary employees. If there are any changes to the profile of activities profile in the practice, the owner should verify that this is covered by the policy. The insurer will be happy to help clarify this.

There are insurance companies that do not differentiate between dental practices and orthodontic practices as far as their policies are concerned.

Where an orthodontist is planning to personally insert miniscrews (an approach which

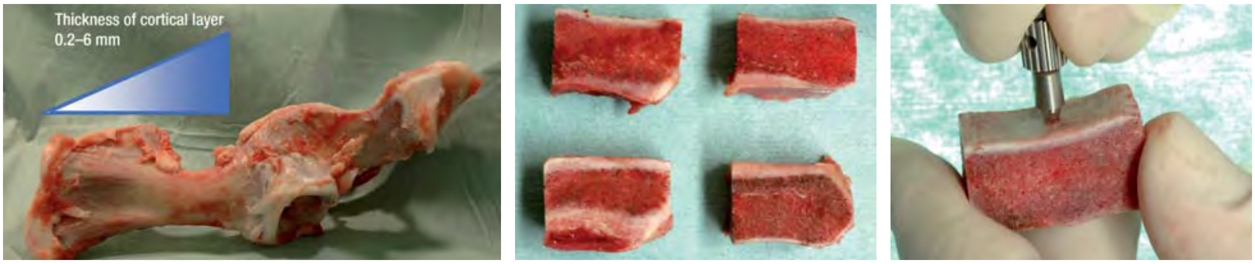
Fig. 6.7: The desired mesialisation of the molars is not possible because of the screw location and the fact that the springs are too short. For further details, see the text.

Overview 6.2

Miniscrews with depth stop

Name of screw	Manufacturer
Aarhus Mini-Implant*	Medicon
AbsoAnchor	Dentos
Ancotek	Tekka
BENEFIT	Mondeal
Infinitas	db orthodontics
LOMAS **	Mondeal
S.I.N.-Implant System	Microparafuso Ortodontico
ST Anchor Screw	Surgi-tec
tomas®-pin	DENTAURUM

* Screw type: system 1.6 and one-point head
** as appropriate to form of insertion



Figs. 6.8a–c: The pelvic bone of a pig is good practice material because of the varying thickness of the compact bone **(a, b)**, and this material can be used to simulate various insertion situations **(c)**.

has many advantages), this is usually automatically covered by the policy. This is the case when the policy specifies 'with implants' or 'with surgery'. In any case of doubt, however, policyholders should always contact their insurers and inform them of the extension of the range of treatments provided, particularly if the policy does not specifically cover maxillary orthopaedic or implant procedures. In this case, the annual premium is likely to be increased by € 20–50 (applicable at time of writing, June 2007).
In order to protect themselves should a claim for negligence be made, orthodontists should ensure that they follow certain basic rules.

Duty of information

Prior to beginning any procedure, the patient must be informed of the nature and effect of potential risks, of alternative treatments and of the consequences if no treatment is provided. It is a good idea to use pre-printed material to gather information on medical history and provide information. These can act as an aide-memoire or prompt when interviewing the patient. Written material should on no account be used instead of the personal dialogue. The printed material used must document (e.g. in the form of a note) that the relevant verbal information has been given to the patient. It is not enough merely to have the signature of the patient, a witness and the practitioner.

Documentation

Documentation, documentation, documentation...is an absolutely essential aspect. Treatment records (patient card, X-ray plates, models etc.) must clearly document the course of the procedure and any problems and complications. Scrupulous and accurate documentation is very valuable if, for example, a legal dispute ensues. Lawsuits are often lost because the documentation is incomplete.

Insurance claims

If a patient suffers an injury or decides to register a claim, it is advisable to get in touch with the policy provider. The insurer will supervise all the financial and legal aspects.

Brief CV

Prof. Dr. Jörg A. Lisson

- Born 1967
- 1986–1991 Dental Education at Hanover Medical School (MHH)
- 1991–1993 Private Dental Practice in Bremen
- 1994–1997 Postgraduate Education in Orthodontics Hanover Medical School (MHH)
- 1995 Doctoral Thesis
- 1997–2001 Senior Officer at the Department of Orthodontics at Hanover Medical School (Head: Prof. Dr. em. Joachim Tränkmann)
- 2001 PhD
- 2001–2002 Director of the Department of Orthodontics at Hanover Medical School
- Since 5/2002 Full Professor, Head and Chairman of the Department of Orthodontics at Saarland University Dental School in Homburg/Saar

Summary

The main parameters that determine the clinical success of a procedure are the bone quality and space available at the planned

Brief CV

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- 1979–1981 Dental technicain, Charitè (Berlin)
- 1984–1990 Study of dentistry, Humboldt Universität at Berlin
- 1990 Doctor degree
- 1990–1992 Assistant at the Prosthodontic Department, Charitè (Berlin)
- 1992–2002 Assistant professor pre-clinical education, University of Witten/Herdecke (UWH)
- 1995–2001 Coordinator of dental aid project in The Gambia
- 1999 Training of Community Oral Health Worker (COHW) in The Gambia
- Since 2002 visiting lecturer at University of Witten/Herdecke
- 2002–2008 Employee of Dentaurum Company, Head of R&D Division
- Since 2008 Employee of DENTSPLY Friadent
- Numerous articles, book chapters and lectures

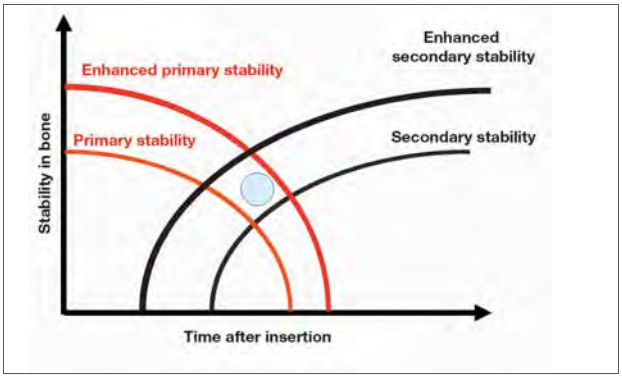

Fig. 6.9: Primary stability decreases while secondary stability increases. There is a critical phase at the point of crossover of the two effects in which there is a risk of screw loss.

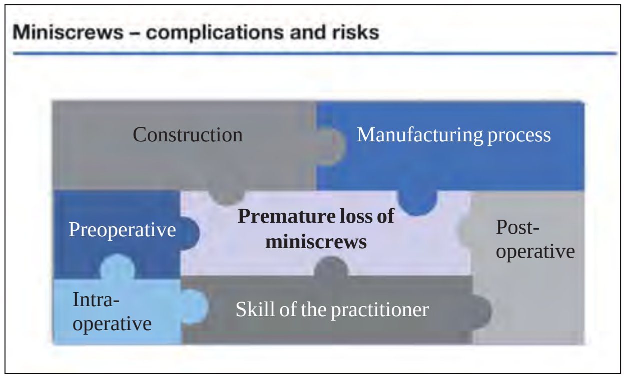

Fig. 6.10: The reasons for the loss of miniscrews interconnect.

insertion site, the use of an insertion technique appropriate to the system employed, and the use of a well thought-out biomechanical concept and the avoidance of inflammation around the miniscrew. There are many reasons for failure, and these are interconnected, rather like the pieces of a jigsaw puzzle (Fig. 6.10).

Concluding remarks on the article series

These six articles cover many aspects of the creation of bone anchorage with the aid of miniscrews. The authors hope that they have achieved the aim set out at the beginning of the series, and have provided the (as yet undecided) practitioner with a compendium of new information and experiences. However, it is not possible to discuss all aspects in full detail even in an extensive series of articles, and we would refer interested practitioners to the relevant literature available. But all theory remains just that if it is not actually applied in practice. We should be pleased if you, our readers, found the courage to use miniscrews on a routine basis as part of your work. And we—Dr. Björn Ludwig, Dr. Bettina Glasl (both of Traben-Trarbach) Dr. Thomas Lietz (of Neulingen) and Professor Dr. Jörg A. Lisson (Clinic of Orthodontics, University Hospital of the Saarland)—wish you every success.

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Editor’s note

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- Established in own private office together with Dr. Björn Ludwig in Traben-Trarbach
- Lectures and posters at congresses
- Numerous publications
- Research and development in the area of mini-implants
- Numerous book contributions and translations

Brief CV

Dr. Björn Ludwig

- Studied dentistry in Heidelberg
- Further training as specialist in orthodontics in private practice and in cooperation with the University Clinic in Frankfurt/Main
- Started his own practice together with Dr Bettina Glasl in Traben-Trarbach
- Papers presented at conventions and posters contributed
- Numerous publications
- National and international advanced training events
- Research and development in the field of mini-implants
- Editor of the reference book “Mini-implants in Orthodontics” (published by Quintessenz, Berlin)
- Numerous book chapter contributions

Injuries to the hard or soft tissue can unfortunately not be entirely excluded when inserting mini-screws. It is therefore preferable to have suitable devices available during the planning phase to minimise the risk of a possible injury or to help evaluate the anatomy. Dr. Björn Ludwig and his team recently presented the X-ray pin (FORESTADENT) as a new orientation aid that makes it possible to find the ideal insertion position.

New X-ray aid for pre-operative diagnostics of skeletal anchorage

By Dr. Björn Ludwig and Dr. Bettina Glasl

Introduction

New techniques and options in jaw orthopaedics are constantly being developed. There are always new trends and new methods that are regarded as fashionable and that attract attention and arouse interest. According to surveys conducted in the USA, mini-implants are currently the biggest trend, followed by self-ligating brackets and digital imaging processes. This contribution combines two of these topics, i.e. the cortical anchorage in combination with imaging processes.

The most common reasons why mini-implants are not standard usage in orthodontics are the need for an anaesthetic and surgical insertion, as well as fear of the risks such as screw loss or damage to adjoining anatomical structures.

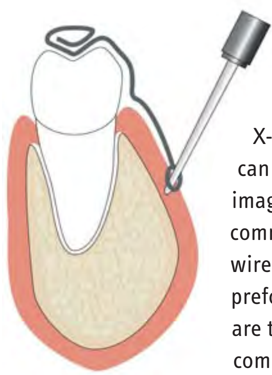

Fig. 1: Sketch of an X-ray device made from bent wire.

X-ray aids

For the above reasons in particular, it helps to have a suitable aid to find the ideal insertion position during the planning phase. This can help to avoid risks and to provide a better overview of the anatomy. The literature describes various X-ray aid systems, which can be combined with diverse imaging processes. The most common aid elements are bent wires—now also available as preformed products—which are temporarily fastened over composite or a silicon wall directly on the tooth or on laboratory templates. One disadvantage of direct attachment in the mouth is the risk of loss or bending before or while taking the control image; the laboratory versions are very expensive and difficult to use. In addition, their use usually involves two patient visits to the practice (Figs. 1 and 2).

Imaging processes

3-D volume tomography is frequently discussed these days and has in the meantime become available to an increasing number of practices. This has significantly increased the safety of dental implantology, but the cost, benefit and the aspect of radiation hygiene must be taken into account when considering the method.

In orthodontics, an orthopantomogram is traditionally used for diagnostic purposes. Further assessment of the findings can be achieved by using orthoradial images of individual teeth obtained with the aid of right-angle technology to provide more accurate results. In the case of 2-D images, distortions, overlays of anatomical structures or their wrong evaluation cannot be entirely avoided for physical reasons. Nevertheless, this re-

Fig. 2: Model including a laboratory-made X-ray device.

Fig. 3: On the X-ray pin made by FORESTADENT with a ball-shaped head and an undercut for dental floss.

mains the medium of choice in the field of mini-implants.

X-ray pin

Based on a pilot and research study carried out in cooperation with the company FORESTADENT*, new orientation aids were developed, which provide as many advantages as possible for pre-operative diagnostics and are economically meaningful, i.e. they should save time and cost. This led to the development of the so-called "X-ray pin",

Fig. 4: FORESTADENT X-ray pin pack of 20 units.

which has all the properties required for use in daily routine.
The X-ray pin is 3.5 mm long and is made of steel. Its tip is conical in shape to facilitate perforation of the gingiva. Its retention in the periosteum offers sufficient hold for a diagnostic X-ray image to be taken. Once it has been removed, the selected insertion point is automatically marked by bleeding, making it easy to exactly locate again. To guard against aspiration of the device, a piece of dental floss is attached to the end of the transgingival part and its end remains outside the mouth, as is the practice in endodontology. The head of the X-ray pin is thicker and corresponds to the shaft diameter of the commonly used mini-implants. The X-ray aids should, however, always be coordinated with the system used to ensure the congruence of the dimensions, for example the OrthoEasy® system made by FORESTADENT and the corresponding X-ray pin. As this is a penetrative process, it is essential to adhere to the hygiene guidelines. All positioning aids are only intended for single use.
The X-Marker® manufactured by DENTAURUM, in comparison, is delivered in individual packaging and comes equipped with dental floss to safeguard against aspiration. However, it is somewhat more expensive than the X-ray pin made by FORESTADENT, which is delivered in packs of 20 unsterilised units that still need to have dental floss attached (they have a special undercut at the head for easy attachment of the ligature) (Fig. 3).
Well-designed miniscrew systems are not only distinguished by the implant itself, but by a well-coordinated conceptual system, which ranges from the instruments to the implants and to the auxiliary products on offer.
The OrthoEasy® pin system made by FORESTADENT and the tomas® pin system made by DENTAURUM both have an integrated X-ray pin (Figs. 4 and 5, Tab. 1).

Fig. 5: Mini-implant system with corresponding X-ray pin (OrthoEasy®, FORESTADENT).

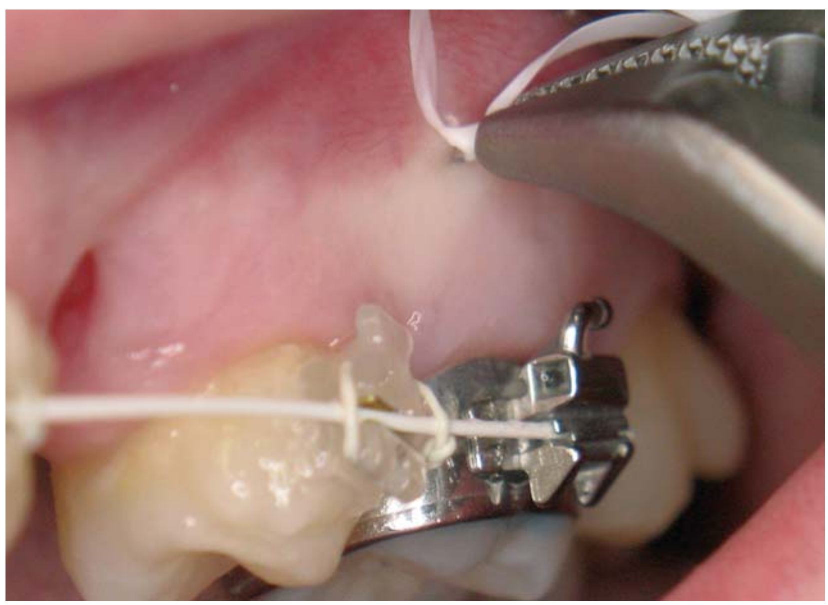

Fig. 6: Anchoring the X-ray pin using Weingart pliers.

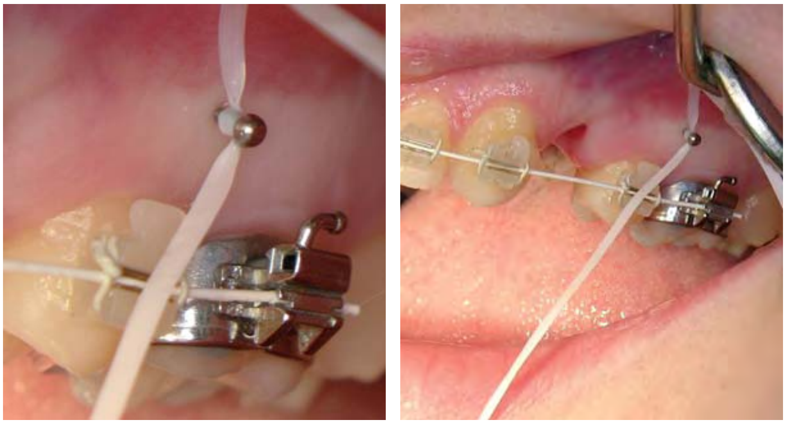

Fig. 7a,b: X-ray pin placed in an ideal position in the attached gingival and secured by tooth saw.

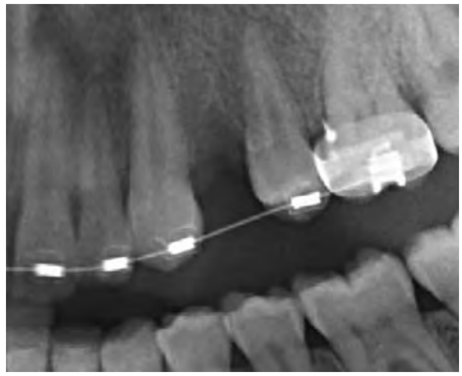

Fig. 8: Control image with X-ray pin. The position relative to the adjoining teeth and the availability of circumferential bone can be easily evaluated.

Fig. 9: After removal of the x-ray pin still a bleeding point stays visible.

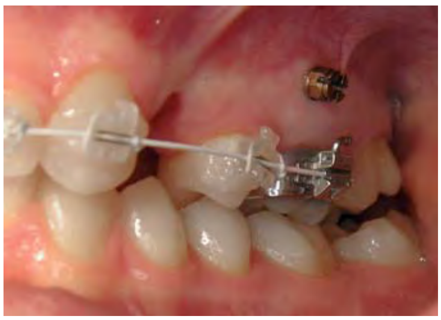

Fig. 10: Placed in mini-implant after corrected position according to the x-ray diagnosis.

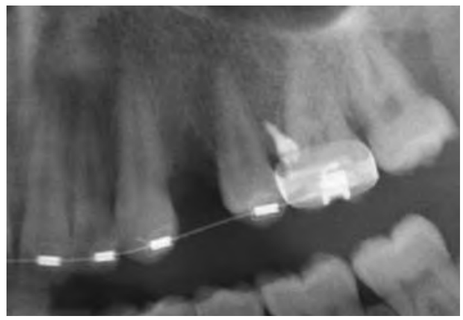

Fig. 11: X-ray check after insertion with sufficient bone retention.

Clinical application

The insertion point is selected in accordance with the planned treatment and the related mechanical aspects and the patient can—but does not have to be—anaesthetised using a local anaesthetic. Using Weingart pliers, the pin is then anchored in the periosteum by penetrating the gingiva.
The X-ray pin should be secured with dental floss. An X-ray can then be taken. After the pin has been removed, the selected point remains marked and the insertion of a mini implant can be carried out.
Not only does the position in relation to the adjoining teeth have to be taken into account, but particular attention must also be paid to the bone available along the vertical axis to ensure that there is sufficient circumferential bone around the mini-implant (Figs. 6–9).

Conclusion and summary

The method of cortical anchorage using mini-implants has the potential of becoming standard practice, as the procedure is more routinely used and a systematic concept is being developed, the mechanical aspects are being simplified by auxiliary products that can be bought ready packaged and the time required to attach and change modules can be optimised. Safe application can be improved by clinical inspection and pre-operative diagnostics. As only accurate X-ray technology will provide an image that can be evaluated, pre-operative X-rays should generally be regarded as critical and should be carried out in a manner that is both as stress-free as possible for the patient and economical. The X-ray pin systems that can be used for this purpose are quick and easy to use and inexpensive. They guarantee time-saving application and render good results in terms of X-ray technology for ideal evaluation of the bone situation and anatomical structures.

Editor's note

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A complete system for all tasks: Cortical anchorage is simple and safe when using the OrthoEasy® pin system (FORESTADENT) and its extensive auxiliaries.

More than just a **miniscrew**

By Dr. Björn Ludwig and Dr. Bettina Glasl

During the past few years a lot about miniscrews have been researched, developed, tested and published. More than 40 systems from different manufacturers and more than 1.000 published studies do not make it easy for the practitioner to find his way through the flood of information. And there is no end in sight. Even if these small tools are already standard components of the orthodontic day-to-day life, new experiences will still be gained, unconsidered aspects illuminated and screw designs optimised. The current compendium gives a comprehensive overview of international study results, significant statements from professional literature and clinical experiences of different practitioners. Gained experiences from the past years and personal conclusions from intense research accompany this compendium. These experiences, undergone in our daily praxis routine, compiled by information exchange or literature studies, led to the development of the OrthoEasy® system in cooperation with FORESTADENT.

Entitlement and primary goal have been to develop an easy and safe system for the daily routine. That should not only help to overcome the practitioner's inhibitions but

documentation label

X-ray pin

logistical rack

ORTHOeasy®

also to implement miniscrews as a standard in each orthodontic practice. At the same time, it should not only offer "high end practices" but also and particularly contractual dentists a safe option for effective treatment.

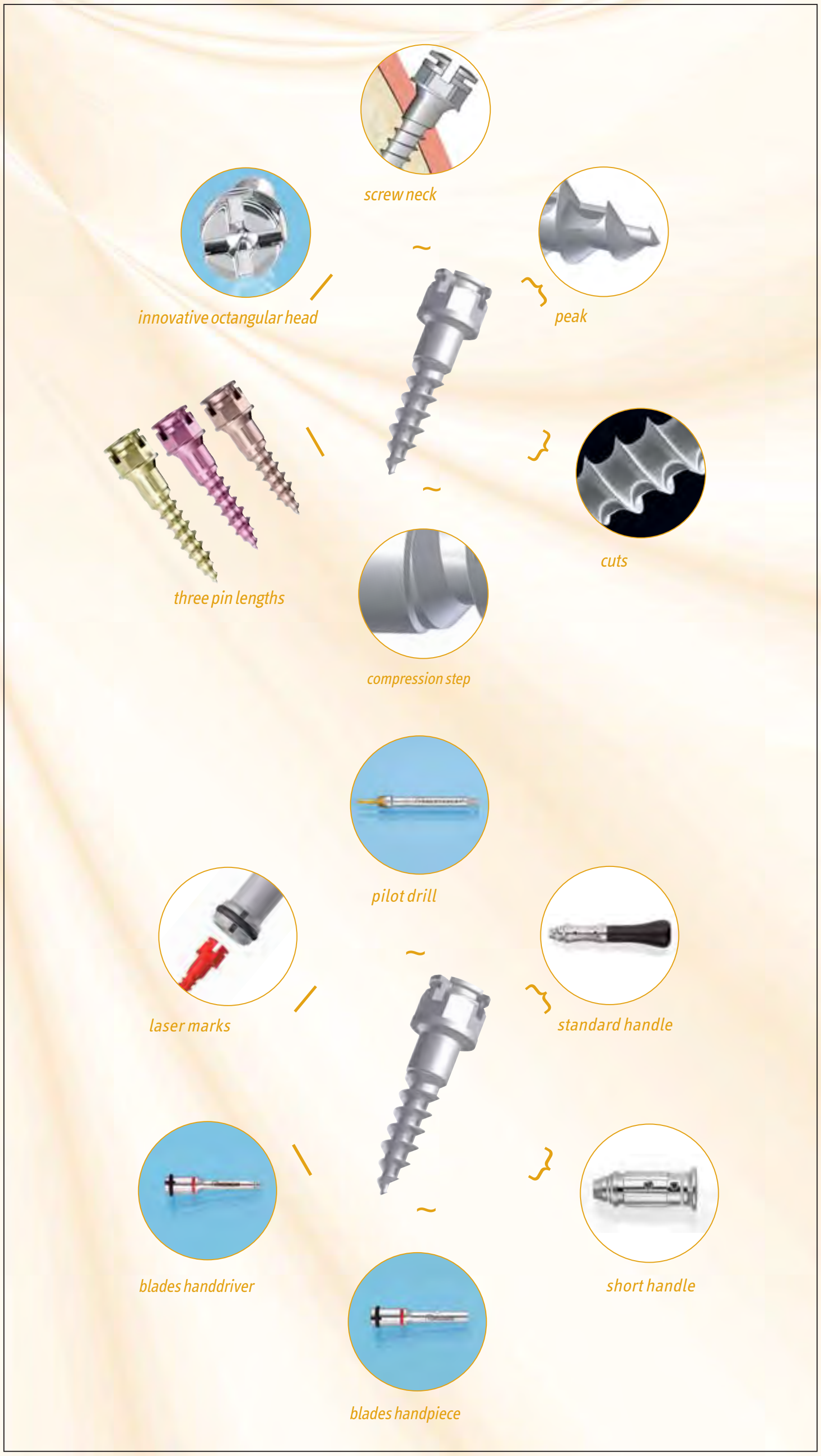
In the following the most important four areas (logistics/diagnostic, screw design, insertion, treatment) of the OrthoEasy® system will be shown in form of diagrams. The compendium informs in a clear and short form about the concept of cortical anchorage.

Logistics/ Diagnostics

The *documentation label* should stay in the sterilisation rack while sterilising and be kept to each screw or respectively be put into the patient file after insertion. In this way the lot identification is guaranteed.

The *logistical rack* is for storing all OrthoEasy® components. The transparent plastic cover ensures a good overview after sterilisation. All components can easily and hygienically be taken out according to the "no touch principle".

The *X-ray pin* can be used for a better orientation prior to the insertion.



Screw Design

The transgingival conic *screw neck* ensures an optimal sealing of the gingiva against germs.
Whereas the special design of the thread *peak* offers safe and easy passage through the gingiva and corticalis.
Shark like *cuts* make a new pitch at every single winding step.
A *compression step* and depth stop at the corticalis increase the stability through mechanical compaction.
The *three* different *pin lengths* are colour-coded (rose: 6 mm, pink: 8 mm, gold: 10 mm) and facilitate orientation.
The *innovative octangular head* is arranged in the familiar bracket design with a .0220 x .0250 slot, versatile through its circular undercut and hence as easy to use as a bracket.

Insertion

The *pilot drill* features a 4 mm grind, which should only pre-drill the bone to minimise the risk of root resorption. It is only necessary in textually compact areas (e.g. anterior lower jaw).
The practitioner can choose between two screw drivers (*short handle* / *standard handle*) and two different blade lengths for the manual insertion. There are also two different blade designs available for the mechanical insertion.
Laser marks help to align the miniscrew slot in such a way that readjustments after removing the blade are not required.

Treatment

Pre-bent *L-anchors* are for simple linkage to the Quick®-Brackets (with auxiliary slot) or to the tooth. *U-anchors* extend to the centre of resistance of the tooth for physical tooth movement (Figs. 1a, b).


Fig. 1a


Fig. 1b


Fig. 2a


Fig. 2b


Fig. 3a


Fig. 3b

Fig. 4a

Fig. 4b

Fig. 5a

Fig. 5b

Fig. 5c

Cross tubes (Figs. 2a, b) allow a simple 90°-clamp-linkage of the vertical miniscrew archwire with the horizontal main archwire. The *Power-Arm* (Figs. 3a, b) targets force at the same height as the centre of resistance and is applicable for en masse retraction and slipping mechanics. By using *molar up-righting spring* (Figs. 4a, b) strongly tipped side teeth can be righted.

Fig. 6

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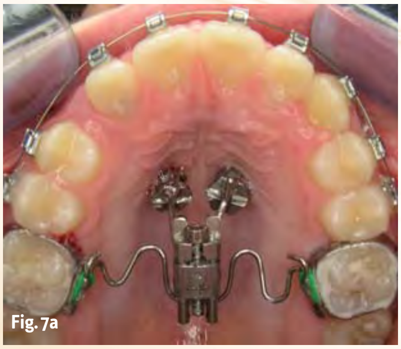

Fig. 7a

The *space jet* (Figs. 5a–c) allows safe, fast and gentle space closing with minimal clinical input.

Individualised Laboratory Parts

The caps of the *laboratory abutments* (Fig. 6) need to be cemented or ligated onto the miniscrew head in order to weld on various laboratory appliances.

Laboratory abutment interlinked to the *FROG appliance* (Fig. 7a) for distallisation and *Hybrid RME* (Fig. 7b) for skeletal transversal expansion.

Brief CV

Dr. Bettina Glasl

- Studied dentistry in Munich
- Postgraduate Studies in orthodontics in private practice and the University of Frankfurt/Main
- Established in own private office together with Dr. Björn Ludwig in Traben-Trarbach
- Lectures and posters at congresses
- Numerous publications
- Research and development in the area of mini-implants
- Numerous book contributions and translations

Fig. 7a

As shown by the individual diagrams, OrthoEasy® is not only a miniscrew but rather a complete anchorage system. The intelligent concept does not only offer an uncomplicated system but also a safe application for the practitioner and the patient.

Brief CV

Dr. Björn Ludwig

- Studied dentistry in Heidelberg
- Further training as specialist in orthodontics in private practice and in cooperation with the University Clinic in Frankfurt/Main
- Started his own practice together with Dr Bettina Glasl in Traben-Trarbach
- Papers presented at conventions and posters contributed
- Numerous publications
- National and international advanced training events
- Research and development in the field of mini-implants
- Editor of the reference book "Mini-implants in Orthodontics" (published by Quintessenz, Berlin)
- Numerous book chapter contributions