Miniscrews—a focal point in practice

Six-part series by Dr Björn Ludwig, Dr Bettina Glasl, Dr Thomas Lietz & Prof. Jörg A. Lisson—Part VI

Complications and risks

Preliminary remarks

The use of miniscrews facilitates many aspects of orthodontic treatments and in some cases actually makes such treatments possible. But miniscrew-based treatments, in common with other 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, which means that the potential and limitations of miniscrews are also ever more apparent.

Fig. 1: There are many possible causes of the premature loss of miniscrews. The most common of these are presentation-related.

Fig. 3: Classification of bone quality according to Misch

Bone quality

Fig. 4a & b: If dental film is used, only the right side technique will supply useful information (a). The use of an angled X-ray technique not only exposes the patient to unnecessary stress, but is also worthless for treatment planning purposes (b).

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 sequence of adverse events is triggered. At first glance, there is frequently no direct connection between the origin and outcome of a problem and/or its complications and its cause. Obviously, there are still several areas that have not been sufficiently researched. 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 1). Because of this, we are reasoning that the patient is informed of the potential risks and the availability of alternative treatments. The most common complication is the loss of a miniscrew.

Success rate/failure rate

How low is the failure rate—or, to put it better, how high is the success rate—in miniscrew procedures? It would be easy to reproduce the figures from published studies, but these are not of interest: for example, the success rate is in the range of 90 to 100 per cent. The published results of clinical observation and ‘studies’ are all within this range. So, do we now know whether miniscrew VI is any good or not? And is this a suitable criterion on which to base the evaluation of a system or therapeutic approach?

A study by Behrens and Wichmann reported failure rates of miniscrews inserted in the lingual mandible, for example, 100 per cent for Dual Top and 70-90 per cent 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 unsuitable. It seems probable that the outcome would be the same for all other mini-screws inserted at this location. It should be borne in mind that it is unusual to draw premature conclusions from figures alone. There are many possible causes for the loss or partial failure of mini-screws. 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 an important factor in determining 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 ultimately 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 per cent, although a practitioner is unlikely to achieve this from the start using miniscrews. There is clearly a 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.

Iatrogenic problems

As Figure 1 and Table 1 show, there is a whole range of possible causes of the loss of a miniscrew. In view of their diversity, it is only possible to consider a few aspects in the following discussion.

Planning and organisation

Careful planning is undoubtedly one of the main keys to success. The same documentation and information required for other orthodontic 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 complications), see Overview 1), diagnosis, and treatment objective. The general conclusions have been adopted from those that apply to implant procedures. The actual effect of these disorders and conditions on the outcome/miniscrew procedures has not yet been determined.

Screw location

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

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

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. 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 prevents or re-
Overview 1

Local contraindications:

- Quantitative and qualitative deficiency of bone at the insertion site
- Insufficient keratinised tissue
- In the mobile mucosa
- On the lingual side of the mandible
- Non-parallel root axes
- Alveolar bone index
- Palatal perforations
- Antibiotic or antifungal agents
- Radiation therapy

General contraindications:

- Compromised immune system
- Therapy with corticosteroids
- Blood coagulation disorders
- Uncountrollable endocrine disorders
- Rhabdomyosarcoma
- Hepatitis cirrhosis

SD

Low

Almost never

Table 1

<table>
<thead>
<tr>
<th>Grade of probability</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

1. Objective causes

1.1. Structural causes

Dependent on system used and can be controlled by the practitioner only in the selection of system.

- Primary stability immediately on insertion

- Secondary stability immediately on insertion

- Screw localisation and tensioning

- Screw too long, perforation of contralateral side

2. Process-related causes

- Selection of the insertion site and the appliance

- Bone quality

- Screw head near mobile mucosa or extraction wound

- Insufficient fixation

- Site in retromolar maxilla

3.2. Phase of therapy

- Primary stability

- Secondary stability

- Insufficient fixation

- Site in retromolar maxilla

3. Patient/post-operative phase

- Malocclusions

- Implantation errors

- Abnormal stability

- Failure of hygiene procedure

4.2. Preparation for insertion

- Contraindication to miniscrews (e.g. in diabetes mellitus)

- Screw too long

- Site in retromolar maxilla

5.2.2. Insertion technique

- Insertion without prior perforation

- Pulpotomy of the tooth

- Insufficient stability

- Site in retromolar maxilla

- Insufficient fixation

6.2.3. Attachment to orthodontic appliance

- Malocclusions

- Implantation errors

- Abnormal stability

- Failure of hygiene procedure

7.1. Patient status

- Blood coagulation status

- Site in retromolar maxilla

- Insufficient fixation

- Abnormal stability

- Failure of hygiene procedure

2. Iatrogenic causes

3. Prosthetic problems

4. Infections

5. Systematic causes

6. Gutta-percha

7. Gingival irritation

8. Inflammation (peri-mucositis, peri-implantitis)

9. Force vectors, unsuitable biomechanical concept

10. Micro-movements

11. Contact with root

12. Insufficient ‘feeling’ for bone and screw

13. Manual vs. machine insertion

14. Screw-in force (> 5 Ncm, > 10 Ncm)

15. Site in retromolar maxilla

16. Screw too long, perforation of contralateral side

17. Screw head near mobile mucosa or extraction wound

18. Insufficient fixation

19. Site in retromolar maxilla

20. Malocclusions

21. Implantation errors

22. Abnormal stability

23. Failure of hygiene procedure

24. Malocclusions

25. Implantation errors

26. Abnormal stability

27. Failure of hygiene procedure

Checklist of the potential causes of the loss of miniscrews

<table>
<thead>
<tr>
<th>Cause of loss of miniscrew</th>
<th>High</th>
<th>Medium</th>
<th>Low</th>
<th>Not applicable</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

2.2.1. Insertion site

- High levels of primary stability

- Site in retromolar maxilla

- Insufficient fixation

- Site in retromolar maxilla

- Malocclusions

- Implantation errors

- Abnormal stability

- Failure of hygiene procedure

3.2. Phase of therapy

- Primary stability

- Secondary stability

- Insufficient fixation

- Site in retromolar maxilla

3. Patient/post-operative phase

- Malocclusions

- Implantation errors

- Abnormal stability

- Failure of hygiene procedure

4.2. Preparation for insertion

- Contraindication to miniscrews (e.g. in diabetes mellitus)

- Screw too long

- Site in retromolar maxilla

5.2.2. Insertion technique

- Insertion without prior perforation

- Pulpotomy of the tooth

- Insufficient stability

- Site in retromolar maxilla

- Insufficient fixation

6.2.3. Attachment to orthodontic appliance

- Malocclusions

- Implantation errors

- Abnormal stability

- Failure of hygiene procedure

7.1. Patient status

- Blood coagulation status

- Site in retromolar maxilla

- Insufficient fixation

- Abnormal stability

- Failure of hygiene procedure

2. Iatrogenic causes

3. Prosthetic problems

4. Infections

5. Systematic causes

6. Gutta-percha

7. Gingival irritation

8. Inflammation (peri-mucositis, peri-implantitis)

9. Force vectors, unsuitable biomechanical concept

10. Micro-movements

11. Contact with root

12. Insufficient ‘feeling’ for bone and screw

13. Manual vs. machine insertion

14. Screw-in force (> 5 Ncm, > 10 Ncm)

15. Site in retromolar maxilla

16. Screw too long, perforation of contralateral side

17. Screw head near mobile mucosa or extraction wound

18. Insufficient fixation

19. Site in retromolar maxilla

20. Malocclusions

21. Implantation errors

22. Abnormal stability

23. Failure of hygiene procedure

24. Malocclusions

25. Implantation errors

26. Abnormal stability

27. Failure of hygiene procedure

Overview 2

Miniscrews with depth stop

<table>
<thead>
<tr>
<th>Name of screw</th>
<th>Manufacturer</th>
<th>Screw type</th>
<th>System type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aarhus Mini implant</td>
<td>Infinitas Orthodontics</td>
<td>Screw-in, conical</td>
<td>S2</td>
</tr>
<tr>
<td>Ashmore Screw</td>
<td>Infinitas Orthodontics</td>
<td>Screw-in, conical</td>
<td>S2</td>
</tr>
<tr>
<td>Ancotek</td>
<td>Infinitas Orthodontics</td>
<td>Screw-in, conical</td>
<td>S2</td>
</tr>
<tr>
<td>Biocronet</td>
<td>Infinitas Orthodontics</td>
<td>Screw-in, conical</td>
<td>S2</td>
</tr>
<tr>
<td>O.K.I.</td>
<td>Infinitas Orthodontics</td>
<td>Screw-in, conical</td>
<td>S2</td>
</tr>
<tr>
<td>Orthodent</td>
<td>Infinitas Orthodontics</td>
<td>Screw-in, conical</td>
<td>S2</td>
</tr>
<tr>
<td>SANA</td>
<td>Infinitas Orthodontics</td>
<td>Screw-in, conical</td>
<td>S2</td>
</tr>
<tr>
<td>SANA Mini-Implant</td>
<td>Infinitas Orthodontics</td>
<td>Screw-in, conical</td>
<td>S2</td>
</tr>
</tbody>
</table>

Otherwise, there is a risk of problems of the sort illustrated in Fig. 7. Here, it is no longer possible to achieve the aim of treatment (mesialisation of the molar). This is because the screws are in the way and as they are in the wrong location, the screws are too short and thus ineffective. The correct position for the screws would have been between teeth 5 and 4. This problem arose because of an amissunderstanding and lack of comminication between the orthodontist and oral surgeon with regard to the aim of treatment and the position 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 a mistake in this case – 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 D5 or D4 (Fig. 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.

The miniscrew must not be in contact with the tooth root. If this happens, the physiological movement of the tooth can cause persistent micro-movements of the screw (Fig. 5). This impairs the healing process and means that secondary stability will not be achieved. No iatrogenic 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 2). It should be

come apparent if the stop touches the bone surface during insertion, providing the signal to stop screwing (Fig. 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 over-insertion, 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 prevent this, 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 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 (>20 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 losses after the first five to ten miniscrew treatments performed by an individual. The personal learning curve can be vastly improved by practising on porcine bone samples (Fig. 8). Various clinical situations can be simulated (bone quality, effect of drilling etc.). This training gives the individual 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.

Primary and secondary stability

The primary stability of a miniscrew in the bone must be good. Screw stability is mainly determined by the cortical layer. The screw elementsinserted with in 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)

- Unsuitable 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 stability 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 second

The regeneration of the bone tissue required to achieve second...
ary stability commences shortly after insertion (Fig. 9). If this process is persistently inhibited (e.g. by micro-movements of the screws), the screw may be lost.

**Force application**

It is probable that using a miniscrew 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, micro-movements of the screws can result. 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. 7).

**Post-operative complications**

**Inflammation**

There is a high probability that a miniscrew will fail if peri-implantitis or peri-mucositis develop. Metritis or osteitis (status of the surrounding tissue, mechanical concept and the prevention of inflammation around the miniscrew. There are many reasons for failure, and these are interconnected, rather like the pieces of a jigsaw puzzle (Fig. 10).

**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 to €5 million. When deciding on the extent of cover required (and thus the premiums that will need to be paid), the particular circumstances of the practice need to be considered. An indemnity insurance policy will also cover the practice’s personnel but may exclude temporary employees. There are any changes to the activities profile in the practice, the owner should verify that this is covered by the policy. The insurer will be happy to clarify this. There are insurance companies that do not differentiate between dental practices and orthodontic practices as far as their policies are concerned.

In cases in which an orthodontist is planning to personally insert miniscrews (an approach that has many advantages), this is usually automatically covered by the policy. This is what the policy refers to when specifying ‘with implants’ or ‘with surgery’. In any case of doubt, however, policyholders should always contact their insurers and inform them of the extent of the range of treatments provided, particularly if the policy does not specifically cover surgical or implant procedures. In this case, the annual premium is likely to be increased by €250 to €500 (applicable at time of writing, June 2007). In order to protect themselves should a claim of negligence be made, orthodontists should ensure that they follow certain basic rules.

**Documentation**

Document the document is an absolutely essential aspect. Treatment records (patient card, X-ray plates, photographs) are evidence that the treatment was carried out. The positioning of attached elements (springs, extension arms) may cause the development of pressure sores or even ulceration of the mucosa. It 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, which can cause failure. In addition to the cleaning technique itself, the frequency and intensity of cleaning are undoubtedly also important. Very frequent cleaning that results in persistent micro-movement of the screw could well be disadvantageous.

**Miniscrews – complications and risks**

Fig. 9: Primary stability decreases while secondary stability increases. There is evidence that the gross of the tests in which there is a risk of screw loss.

Fig. 10: The reasons for the loss of miniscrews are related.

**Insurers**

The main parameters that determine the clinical success of a procedure are the bone quality and space available at the planned insertion site, the use of an insertion technique suitable for the system employed, and the use of a carefully considered biomechanical concept and the prevention of inflammation around the miniscrew. There are many reasons for failure, and these are interconnected, rather like the pieces of a jigsaw puzzle (Fig. 10).

**Concluding remarks**

These six articles cover many aspects of bone anchorage using miniscrews. The authors hope that they have achieved the objectives set out at the beginning of the series and provided the (as yet undecided) practitioner with a comprehensive overview of all the new information and experiences. However, it is not possible to discuss all aspects in detail, even in an extensive series of articles; thus, we refer interested practitioners to the relevant literature. But all theory remains just that if it is not applied in practice. We should be pleased if you, our readers, found the courage to use miniscrews routinely in your work. And we—Dr Ludwig, Dr Glad (both Trauten-Trubach) Dr Lüttge (Niesingen) and Prof. Linson (Clinic of Orthodontics, Saarland University Hospital)—wish you every success. 

Contact Info

Dr Björn Ludwig can be contacted at bludwig@kieferorthopaedie-mosel.de.