The handle http://hdl.handle.net/1887/54689 holds various files of this Leiden University dissertation

Author: Verweij, Jop
Title: Bilateral sagittal split osteotomy: risk factors for complications and predictability of the splitter-separator technique
Date: 2017-09-12
Discussion and future perspectives
DISCUSSION AND FUTURE PERSPECTIVES

Aims of the thesis

This thesis aimed to investigate the risk of complications associated with bilateral sagittal split osteotomy (BSSO), performed with a splitter and separators. Specific risk factors for intra- and postoperative complications as well as factors influencing the predictability of the technique were analysed in order to increase predictability of the split and minimise the risk of complications.

The elective nature of BSSO demands a reliable and predictable procedure with minimal risk of complications. Individual patient counselling using patient-specific information regarding the benefits and risks of the procedure are also vital in this process.

In this thesis, risk factors for common complications associated with BSSO were assessed through a systematic review of the literature. Furthermore, the occurrence of complications with the splitter-separator technique and risk factors for these complications were investigated through retrospective studies. The patterns of lingual fractures during BSSO and the predictability of the lingual fracture with our splitter-separator technique was investigated and compared with techniques using other instruments (i.e. mallet and chisels) or other osteotomy designs (i.e. angled osteotomy design) in cadaveric studies.

General considerations regarding the technique

In the research that was conducted in this thesis, BSSO was performed according to the Hunsuck\textsuperscript{1} modification using a sagittal splitter and separators.\textsuperscript{2, 3} Rigid fixation was usually performed using three bicortical screws unless the use of miniplates was indicated.

When the BSSO technique was introduced by Schuchardt\textsuperscript{4} and Obwegeser\textsuperscript{5}, the sagittal split was performed with a mallet and chisels. Since then, different modifications of the osteotomy design have been proposed. Dal Pont\textsuperscript{6} suggested advancing the buccal bone cut towards the distal border of the second molar to increase bone contact surface between the mandibular segments. Hunsuck\textsuperscript{1} modified the lingual bone cut and was the first to complete the sagittal split with a controlled lingual fracture instead of completely chiselling through the mandible. In this design, an inferior border cut through the caudal cortex was performed. The importance of this bone cut in the caudal mandibular cortex, aimed to promote predictable splitting, as well as the importance of biological factors, such as minimal periosteal elevation, were subsequently emphasised by Epker\textsuperscript{7}. With these improvements, the basic components of the contemporary osteotomy design for the sagittal split were in place.\textsuperscript{8} However, important innovations were still to come.

The first decades after its introduction, BSSO was fixed using wires and intermaxillary fixation.\textsuperscript{1, 4-7} Innovations in fixation techniques, however, introduced the use of rigid fixation by bicortical screws or monocortical miniplates.\textsuperscript{9-11} This minimised the need for intermaxillary fixation, thereby reducing patient discomfort and making the procedure much more patient friendly. Rigid fixation furthermore improved the stability and reliability of the outcome after BSSO.\textsuperscript{9-11}

The introduction of BSSO using prying and spreading techniques meant another important innovation for the procedure.\textsuperscript{2} The most important reason for this improvement was the risk of iatrogenic damage to the inferior alveolar nerve when using chisels during BSSO.\textsuperscript{12} Different instruments can be used in these prying and spreading techniques.\textsuperscript{13, 14} In our opinion and experience, the sagittal splitter and separator are the most well-designed instruments to perform a prying and spreading technique.\textsuperscript{3}

Nevertheless, complete control over the lingual fracture during BSSO is still not achieved and complications do still occur. This thesis aims to elucidate the factors influencing the lingual fracture and common complications associated with BSSO.
**Neurosensory disturbances**

Permanent neurosensory disturbance of the lower lip is one of the most important complications associated with BSSO, especially since neurosensory alteration has a serious impact on the patient’s daily life. It presents as either dysesthesia (pain), paresthesia (altered sensation), hypoesthesia (reduced sensation) or anesthesia (no sensation), of which hypoesthesia is the most common presentation. In most cases, normal sensation returns shortly after BSSO. If neurosensory disturbances are still present one year after surgery, they are considered permanent.

Altered sensation is a side effect of BSSO that was described shortly after the introduction of the technique. The inferior alveolar nerve (IAN) runs through the mandible and therefore the risk of iatrogenic nerve damage during splitting of the mandible was soon evident. Early techniques performed the sagittal split with chisels, which is still the norm in several clinics today. The use of sharp instruments near the mandibular canal is associated with a risk of direct iatrogenic nerve damage, especially when tapping chisels along the inner side of the buccal cortex. Sudden forces that are exerted on the mandible when hitting an instrument through the bone, can furthermore cause indirect damage to the IAN. More subtle prying and spreading techniques cause less sudden forces around the nerve and minimise the risk of altered sensation. These prying and spreading techniques are generally accompanied by a lower risk of permanent neurosensory disturbance after BSSO.

Nevertheless, the occurrence of neurosensory disturbances after BSSO is multifactorial. Important surgical factors that can cause nerve damage include: stretching of the IAN during medial dissection near the mandibular foramen, laceration of the IAN during the vertical bone cut when the nerve is positioned near the buccal cortex, puncturing of the IAN due to sharp bone spicules between the mandibular segments, or compression on the IAN due to rigid fixation. The surgeon should be aware of these important factors in order to prevent neurosensory disturbances as much as possible.

Several patient factors might also play a role in the development of altered sensation. These factors are furthermore vital in individual patient counselling, when informing patients about their risk of complications associated with BSSO. Specific mandibular morphology, for example a long mandibular angle or low body height, could predispose neurosensory disturbance of the IAN. However, the most frequently mentioned risk factor for altered sensation after BSSO is the patient’s age. Older patients report significantly more neurosensory disturbance after BSSO than younger patients. Older patients have furthermore been reported to experience more burden in daily life because of persisting neurosensory disturbance. The effect of age on the risk of altered sensation after BSSO is clearly demonstrated in Chapter 3. The incidence of neurosensory disturbances after BSSO was especially low in patients that were younger than 19 years (4.8% per patient). Therefore considering BSSO at a young age can be advocated, in an attempt to reduce the risk of this complication. These findings furthermore enable correct preoperative counselling and provides patient-specific information.

**Bad splits**

Unfavourable fracture patterns, also known as bad splits, can complicate the sagittal splitting procedure. This can be frustrating for the surgeon, but usually causes no long-term consequences for the patient. Bad splits do however frequently necessitate additional fixation techniques, including intermaxillary fixation in rare cases. Seldom, the operation even has to be ceased and re-BSSO can be performed at least six months later.

Bad splits are subdivided in relatively frequently occurring buccal- or lingual plate fractures, and more infrequently occurring fractures of the coronoid process or condylar neck with possible extension into the condyle. Buccal- and lingual plate fractures are further subdivided in horizontal or vertical fractures.
The surgical technique plays an important role in the development of bad splits. Careful application and subsequent control of the bone cuts is necessary to assess the completeness of the performed bone cuts before using the splitting forceps. An incompletely cut inferior border or too high horizontal bone cut could predispose bad splits. It could furthermore be hypothesised that the surgical technique with splitter and separators is accompanied with a different risk of bad split than traditional techniques with chisels. This thesis therefore investigated the incidence of bad split after BSSO with splitter and separators. Chapter 4 showed that the splitter-separator technique is associated with an incidence of bad split of 2.0% per sagittal split osteotomy (SSO). This is well within the range that is reported in the literature (0.5-5.5% per SSO). BSSO with splitter and separators is thus associated with a risk of bad split that is similar to the risk of bad split with other techniques.

Several risk factors for bad splits have been reported. Increasing age has been reported as a risk factor for bad splits. However, there is still no robust evidence that patient age influences the risk of bad split. The presence of third molars has also frequently been identified as a risk factor for bad split during BSSO. The presence of a third molar makes the surgical procedure more difficult. In Chapter 7, third molars were found to increase the risk of bad split but not the risk of other complications. Nevertheless, other authors found no relation between the presence of third molars and bad split. Therefore, the choice to remove third molars prior to surgery remains debatable. Some authors advocate the removal of third molars at least six months prior to BSSO, in order to facilitate an easy and predictable procedure. Other authors, however, propose removing third molars during BSSO to spare the patient one or two unpleasant additional surgical procedures before BSSO. Factors that could influence this decision of third molar removal either during BSSO or six months preoperatively include the patient’s age, the experience of the surgeon, and the spatial positioning of the third molars.

Removal of osteosynthesis material

Rigid fixation has been introduced in the 1970’s. Since then, it has become standard to fix the mandibular segments after BSSO with either bicortical screws or monocortical miniplates. This eliminated the routine need for intermaxillary fixation. One common complication after BSSO is the need to remove this titanium osteosynthesis material because of symptoms, such as infection, palpability of the hardware, or other subjective complaints. These symptoms cause significant morbidity for the patient and result in additional procedures after BSSO. Therefore, removal of osteosynthesis material should be minimised as much as possible.

Chapter 5 reported a comparison of the removal rates for screw fixation and plate fixation, showing that bicortical screws are removed remarkably less than monocortical plates.

These findings could be a reason to perform fixation after BSSO with bicortical screw fixation instead of monocortical plate fixation. However, other aspects of the two techniques are also important. Favourable aspects of plate fixation are that it can be fixed intra-orally without the need for a stab incision in the skin, plates require less precaution to avoid excessive rotation of the proximal segment, and there is no risk of damaging the inferior alveolar nerve with monocortical fixation. On the other hand, favourable aspects of bicortical screws are the fact that they are less expensive than miniplates, and the risk of palpability of the hardware or chronic irritation is lower. When bicortical screws are used, it is important to perform position fixation without compression of the mandibular segments. Lag screw fixation has been shown to cause compression of the inferior alveolar nerve between the mandibular segments and subsequently predispose neurosensory disturbances.
Discussion and future perspectives

**Osseous mandibular inferior border defects**

Mandibular inferior border defects are an unaesthetic complication, wherein a bone defect postoperatively develops at the caudal end of the vertical bone cut. BSSO is aimed to restore a class I occlusion with good function, but usually also improves facial harmony and aesthetics. It is evident that in this process, the occurrence of inferior border defects should be avoided.

Several risk factors can predispose osseous inferior border defects, such as large mandibular advancements and inclusion of the full thickness of the mandibular border in the split (i.e. a type II split). Chapter 6 confirmed these earlier reported risk factors and furthermore showed that increased clockwise rotation of the occlusal plane and significant cranial rotation of the proximal mandibular segment were relevant risk factors for inferior border defects.

The surgical technique could also play a role in the occurrence of osseous inferior border defects. Chapter 8 showed that in BSSO, the chisel-technique and splitter-separator technique result in different lingual fracture patterns (i.e. type of split). Fractures started through the caudal cortex more frequently when using chisels compared to splitter and separators. The splitter-separator technique could therefore facilitate type II splits and subsequently predispose osseous inferior border defects.

The clinical consequences and unaesthetic effects of these complications are yet to be determined. When an unaesthetic mandibular inferior border defect is present, secondary reconstruction techniques to correct the contour of the mandibular border can be performed, for example using Medpore implants or using autologous bone or bone substitutes with a (titanium-reinforced) membrane.

**Lingual fracture patterns and predictability of the split**

In the traditional osteotomy design, a lingual, sagittal, and buccal bone cut are placed just through the cortical bone in order to perform a controlled fracture in the lingual cortex. Several authors furthermore propose performing an inferior border cut through the caudal cortex extending to the lingual side in order to predispose a start of the fracture line in the lingual cortex. Subsequently, the proximal and distal mandibular segments are mobilised.

Different variations of the osteotomy design are used in BSSO, and the (horizontal) lingual bone cut and (vertical) buccal bone cut can be modified with regard to the length and angulation of the bone cuts. Some authors even advocate performing an additional inferior border osteotomy towards the mandibular angle. Establishing the optimal osteotomy design by rearranging the bone cuts or even adding additional bone cuts could reduce the risk of bad split and improve the predictability of the technique. These differences in the bone cuts of the osteotomy design of BSSO can furthermore result in different lingual fracture patterns. Plooij et al. categorised these fracture patterns in their lingual split scale (LSS). They described a ‘true Hunsuck’ vertical fracture line to the inferior border of the mandible (LSS1), an ‘Obwegeser-Dal-Pont’ horizontal fracture line to the posterior border of the ramus (LSS2), and a fracture line through the mandibular canal to inferior border of the mandible (LSS3). Unfavourable fracture patterns were categorised as LSS4 splits.

Furthermore, during BSSO the bone cuts are not always performed completely as planned, because of limited visibility and little workspace on the lingual side of the mandible. The complete performance of the bone cuts of the osteotomy design is an important factor in the development of the lingual fracture and the risk of bad splits. When the vertical bone cut is performed incompletely and ends in the buccal cortex, it has shown to predispose bad splits. When the bone cut either ends in the caudal cortex or an inferior border cut extending into the lingual cortex is performed, the risk of bad split is relatively low. In Chapter 10 of this thesis, in a prospective observational cone-beam computed tomography study, the different lingual fracture patterns after
BSSO were examined. There was no significant association between the length of the inferior border cut in the lingual cortex and the lingual fracture patterns. More research is needed to further investigate the exact association between the osteotomy design and the lingual fracture to increase the predictability of the BSSO technique.

**Future perspectives**

This thesis investigated different risk factors for complications associated with the BSSO technique with sagittal splitter and separators. Nevertheless, complications do still occur and further research should be aimed at increasing the predictability of the technique and reduce the risk of adverse outcomes even more.

The splitter-separator technique is associated with a low incidence of permanent neurosensory disturbances after BSSO. Future clinical research should however aim for further reduction of this important complication of BSSO, as neurosensory disturbances cause the most morbidity and dissatisfaction for patients. Innovations such as CBCT-analysis and piezo-surgery might help minimize the risk of neurosensory disturbances as a result of BSSO.

The development of different lingual fracture patterns remains largely unexplained. Future research aimed to identify predictors for specific lingual fracture lines could help to improve the predictability of the technique and help better understand the occurrence of bad splits. Patient-specific planning with regard to the osteotomy design could also help promote an easy, predictable splits and prevent complications. Prospective research exploring the ideal orientation and arrangements of the bone cuts in BSSO, and the relation between the lingual fracture patterns and complications could further increase the success of BSSO.
REFERENCES


Discussion and future perspectives


