# Modification of the mandibular split based on a physical model

# Valorisation Addendum

## *Introduction*

The most common facial deviations are mandibular retrognathism (the mandible is in a backward position in relation to the maxilla, creating an excessive overbite), prognathism (the mandible is in a forward position to the maxilla, creating a negative overbite or lantern jaw) or an open bite with no vertical overlap between the incisors. Prevalence depends mostly on genetical and racial background. Prognathism is found more frequently in Japanese, Chinese, and Korean people[1,2] and less common in sub-Saharian Africans.[3] Some prominent families like the Austrian royal family von Habsburg are well known for their typical facial appearance with a dominant, prognathic chin.[4] In the US about 20% of the population is diagnosed with facial deviations, with 2% severe enough to be in need for surgical correction.[5]

Data about the prevalence of retrognathism are almost impossible to obtain. Proffit describes a ratio of 15 patients with retrognathism to one with prognathism in the United States.[5] Retrognathism is frequently associated with an obstructive sleep apnea syndrome (OSAS)[6] that can lead to an abundancy of severe negative effects in daily life.[7] There is no broad-based study available about the prevalence of facial deviations in the Netherlands or in Europe. Some European studies on local populations report a prevalence of facial deviations of about 0.4 - 4%.[8]

The therapy of these deformations consists of orthodontic treatment in combination with surgical treatment, if indicated. Surgery corrects the position of the maxilla or mandible. The jaw in question is detached from the surrounding facial skeleton, then re-positioned and re-fixated by means of osteosynthesis. The first surgical corrections were performed in the mandible in the beginning of the last century[9,10]. Nevertheless, serious complications such as facial palsy, non-union of the bone segments, numbness of the lip and chin, and skeletal relapse were common.[11]

The sagittal split osteotomy, which had been introduced in 1955,[12] is an operation technique in which the mandible is fractured without harming the inferior alveolar nerve that is embedded inside the mandibular body. Non-union of the bone segments is highly reduced due to large overlapping bone segments. The facial nerve does not have to be exposed, because of the exclusively intraoral approach. The disadvantage of this technique is the poor view of the operation field with a non-accessible posterior part of the mandible. As a consequence, the mandible may not fracture in the correct way (unfavorable split). However, within the last 50 years this operation technique became the golden standard to correct mandibular deviations. Several modifications of the original technique[13-16] led to further improvements. Unfortunately, complications are still present nowadays as depleted lip and chin sensibility or the unfavorable split. The importance of the complications is obvious by the numerous publications over the last years.[17-25] Both complications are linked with each other. The better the preparation of the planned fracture the more chiseling is necessary. Chiseling puts the inferior alveolar nerve at a higher risk of damage with possible more numbness of the lip and chin. Studying the bio-mechanics of the sagittal splitting procedure, as it is carried out in this thesis, helps to optimize the surgical technique and to reduce possible complications. Less complications result in a shorter hospitalization and a quicker recovery.

### *Results*

The development of a test system enabled us to simulate the sagittal split osteotomy in-vitro. As it can be used in animal and human specimen alike resources can be used effectively in a responsible manner. This system offers the opportunity to explore different surgical techniques and to study the underlying biomechanical process in depth. If the planned fracture lines of the split are prepared with thin instruments, these fine cracks work as a stress riser. Thus, the split can be performed with smaller forces. Stress raising is a well-known phenomenon in material science and industrial design. Another aspect of this study is the validation of the inferior border osteotomy. Although difficult to approach in-vivo, it facilitates the splitting of the mandible substantially. It even allows the surgeon to spare the inferior alveolar nerve during the chiseling procedure. Keeping the nerve aside the risk of damage is reduced significantly, eventually reducing one of the most common complications of the sagittal split osteotomy, a persistent numbness of the lip and chin.

### *Clinical Implications*

This study examined the particular surgical technique of the sagittal split osteotomy of the mandible. Because of its elegant, but nevertheless complicated nature, it remains one of the key operations in orthognathic surgery and in cranio-maxillofacial surgery. Orthognathic surgery comprises facial and orthodontic corrections in syndromal and non-syndromal patients, in patiens with cleft-lip-palate, but increasingly also corrections in OSAS patients. A safe and predictable therapy of these pathologies, as the modified sagittal split osteotomy is, reduces complications and consequently costs and morbidity.

### *Sharing Knowledge*

One key-element in the facilitation of the sagittal split procedure is the addition of the inferior border osteotomy. Because of the limited access to this anatomical region special care and special designed instruments are necessary. To achieve this goal, this study was started in cooperation with the Institute of Material Science at Ruhr-University Bochum, Germany. High quality alloy was used to design a prototype of a rotating saw. It became evident that the material characteristics of Nickel-Titanium (NiTi) alloy, a shape memory alloy, could not sustain the mechanical stress of high speed rotation in combination with a strong curved steering, that was necessary due to the limited space available. Everybody learned from each other how to identify problems, tackle and solve them. All results have been commonly shared in scientific publications. They have been presented at national and international congresses and there will be more publications in the future.

*Future Perspectives*

One key element of this study was the development of a test rack to split cadaveric animal or human mandibles in-vitro. The validation showed reliable and reproducible results for both specimens. The data should allow for development and validation of a finite element method (FEM).

A reliable FEM does not exist at the moment, because of the complex structure of the human mandible. Different facts such as cancellous and cortical bone, roots of teeth, impacted molars, the alveolar canal with the inferior alveolar nerve enclosed and the interaction of all these components under stress prevented its development so far.

FEM transfers the test environment from the real world to a virtual one. It allows easier and cheaper testing. The individual split osteotomy can be pre-operatively tested. In addition to the clinical and scientific improvements, the FEM can be incorporated in the development of virtual reality facilities. These facilities will allow surgeons to learn, practice and improve their skills to perform a safe sagittal split osteotomy.

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