J Stomatol Oral Maxillofac Surg xxx (2018) xxx–xxx

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Technical Note

Current status of surgical planning and transfer methods in orthognathic surgery

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ARTICLE INFO

Article history:
Received 4 November 2017
Accepted 14 February 2018

Keywords:
Orthognathic surgery
Transfer
Virtual surgical planning (VSP)
Surgical navigation
CAD/CAM splints
Surgical splint

ABSTRACT

Since the advent of orthognathic surgery major efforts have been made to render these surgical procedures more reliable, accurate, reproducible, and shorter. Such improvements imply the enhancement of surgical planning (SP) techniques and optimization of SP transfer tools. Most widespread current SP methods are based on physical examination/anthropometric measurements combined with cephalometric analysis. Most surgeons currently use handmade acrylic surgical splints or sometimes freehand surgery as transfer tool. The emergence of virtual surgical planning (VSP) procedures gave birth to several modern transfer tools, such as computer-assisted design and manufactured (CAD/CAM) splints, CAD/CAM splints with extra-oral bone support, customized miniplates, and surgical navigation. This article classifies and describes these emerging transfer tools, therewith underlining their advantages and drawbacks.

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1. Introduction

Orthognathic surgery (OS) consists in repositioning the maxilla, mandible/chin, and their bone segments with a threefold objective – orthodontic, functional, and esthetic. The aim of this technical note is to summarize the most widespread and promising surgical planning (SP) and transfer methods.

2. Orthognathic surgical planning

SP methods consist in three main, non-mutually exclusive approaches or setups: (1) cephalometric analysis, (2) clinical/anthropometric SP, and most recently (3) the virtual setup.

2.1. Cephalometric planning

Cephalometry is the science of radiologically-based SP. Various cephalometric techniques exist, each relying on its own intellectual approach and specific pros and cons. Cephalometric analysis was initially described with planar cephalograms but also shifted in recent years to 3D imaging.

Consistency and rational aspects confer the cephalometric planning its main asset, while making it a formidable tool among scantily-experienced surgeons.

On its downside lies the unrealistic expectation from a setup to be one-size-fits-all. Also, most cephalometric techniques do not take soft tissue into account – an obvious shortcoming within the esthetic purpose of OS.

2.2. Clinical surgical planning (CSP)

Clinical examination in OS consists in anthropometric measurements designed to detect esthetic stigmata of maxillo-mandibular disproportions in the facial soft mask, by static and dynamic analyses.

The sagittal dimension is adjusted by profile analysis, including dental occlusion. The vertical dimension is adjusted by incisor exposure and global facial height. In frontal view, the occlusal plane should be parallel to the bi-pupillary line. The incisor point is centered on the vertical reference plane, while avoiding misguidance by a deviated nose or asymmetric face. The transversal dimension is mainly adjusted based on plaster models. Radiographic examination is also of great help in estimating rotational movements of the occlusal plane and confirming clinical impression.

On the basis of this analysis, the clinician is able to produce a quantitative SP. Because of its practicality and efficiency, CSP is probably the most widespread of the three approaches. Moreover,

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https://doi.org/10.1016/j.jormas.2018.02.001
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Please cite this article in press as: Pascal E, et al. Current status of surgical planning and transfer methods in orthognathic surgery. J Stomatol Oral Maxillofac Surg (2018), https://doi.org/10.1016/j.jormas.2018.02.001

esthetic considerations are omnipresent, thus perfectly fitting modern OS perspectives.

On the other hand, some object to the lack of accuracy and reproducibility of CSP and feel that it should be reserved to more experienced surgeons.

2.3. Virtual surgical planning (VSP)

To date, VSP is not an alternative to traditional methods, but an ancillary tool to manage the most challenging cases. The digital environment allows combined bone and soft tissue simulations, as well accurate quantitative measurements. VSP is also a prerequisite for the modern transfer tools discussed below, i.e., computer-aided designed and manufactured (CAD/CAM) splints, customized miniplates, and navigation.

VSP is a powerful tool capable of tackling facial asymmetries and multi-dimensional disproportions. It allows performing mirroring or multiplying virtual simulations without altering the initial model [1]. Furthermore, dematerialized medical records make remote cooperation between professionals easier. VSP may also become an illustrative tool in doctor-to-patient communication.

However, VSP is time-consuming as it may require between 45 minutes and 5 hours per case [2,3]. VSP is not infallible as difficulties persist in managing virtual dental occlusion, bone conflicts, and chiefly soft tissues simulations. Finally, VSP requires expensive computer equipment and software, i.e., around 80 000 € for the setup [2]. Thus, VSP is currently not sufficiently affordable to be ubiquitously used in the outpatient private practice setting, yet it undoubtedly boasts the potential to deal with complex cases and progressively become the gold standard.

3. Transfer in orthognathic surgery

'Transfer' in OS stands for the clinical application of OS planning. This article will discuss the six currently available transfer methods, i.e., freehand surgery, traditional handmade acrylic splints (HMAS), CAD-CAM splints, CAD-CAM splints with extra-oral bone-borne support (EOBS), custom-made fixation miniplates (CFMP), and navigation-assisted surgery. Fig. 1 illustrates how these processes interplay.

3.1. Freehand surgery

Freehand double-jaw surgery is the most basic bone-segment repositioning concept. Surgeons estimate the osteotomized bone repositioning without relying on any specific tool but their own experience and clinical impression.

The surgeon being the sole intermediate between SP and its technical application is the main advantage of freehand surgery. Moreover, there is no additional cost of specific transfer tools. Intraoperatively the surgeon is attentive to bone-segment repositioning as well as last-minute subtle positioning adjustments tailored by the soft-tissues response. This empirical transfer method is also time-saving preoperatively because no transfer tool manufacturing is needed. It is totally acceptable and presents several appreciable upsides particularly for experienced surgeons.

Nonetheless, the time saved preoperatively is traded off for longer surgery duration: the surgeon performs intraoperative measurements and determines the position of the maxilla or mandible by trial and error. Bone segments have to be adjusted with limited visibility under the swollen soft tissue. Freehand repositioning is not an accurate transfer method, especially for rotational movements of the occlusal plane. Moreover, maintaining bones segments in position during osteosynthesis is trickier, especially in large-amplitude movements or segmented Le Fort I osteotomy.

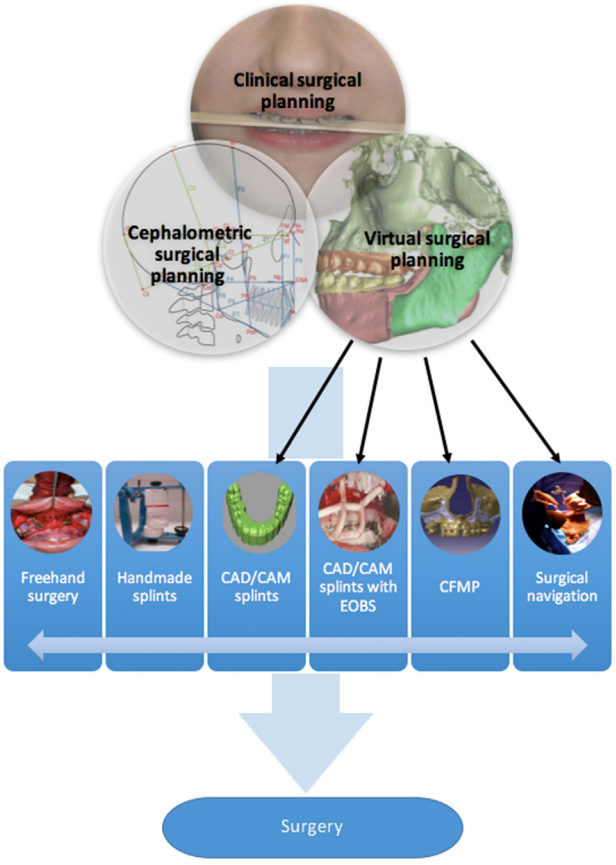

Fig. 1. Surgical planning (SP) may be based on clinical measurements, cephalometric analysis, and virtual surgical planning (VSP). Six main tools are nowadays available for transfer of SP: freehand surgery, handmade acrylic splints, CAD/CAM splints, CAD/CAM splints with extra oral bone-borne support (EOBS), customized fixation miniplates (CFMP), and surgical navigation. CAD/CAM splints, CTMPs, and navigation arise necessarily from VSP.
Illustrations references: CAD/CAM splint [3], CAD/CAM splint with EOBS [9], CFMPs [11], surgical navigation [14], with kind permission of Elsevier Masson.

3.2. Traditional handmade acrylic splints (HMAS)

Surgical splints are traditionally hand-manufactured by dental technicians using plaster models and probably constitute the most widespread transfer tool in OS. The splint's principle is to register and restore the relative position between maxilla and mandible. In two-jaw surgery the osteotomized maxilla is repositioned and fixed using a splint that takes the mandibular dental arch as reference, or vice-versa, regardless of which jaw is operated on first so long as a splint is designed for it. Two splints are required for two-jaw surgery – an intermediate and a final splint. Occlusal splints contain all relative spatial information except the global vertical dimension, which is left up to the surgeon's intraoperative assessment.

Model surgery is quite accurate and doesn't necessitate expensive equipment. The stability conferred by occlusal wafers is also of great help in the bone fixation stages.

An obvious drawback of HMASs is the surgeon's reliance on technicians. HMASs only yield the relative position between maxilla and mandible but no spatial information about their position relative to the skull base. Finally, they don't confer global vertical guidance. Thus, large discrepancies have been reported

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