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Modification of surgical and positioning splint for orthognathic surgical treatment of facial asymmetry

Short Communications

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Recent bibliometric analysis revealed that contemporary studies related with orthognathic surgery topics are mostly concentrated around usage of computer–aided technologies during complex treatment, virtual planning and modifications of surgical splints with the aim to personalize treatment sequence [1, 2]. Even though virtual treatment planning and use of 3D printing technology have not became obligatory within orthognathic surgery, it is already established that such approaches largely increase level of treatment individualization and help to achieve better patient-oriented outcomes [3]. Moreover, patients treated with virtual surgical planning were characterized with more symmetrical frontal view than those treated by traditional surgical planning, even though improvements with quality of life were the similar among above mentioned groups of subjects [4].

Nevertheless, orthognathic surgical treatment of facial asymmetry cases remains one of the most complex clinical procedures in the maxillofacial surgery even considering all the advantages, which may be received with the use of digital dentistry instruments [5, 6]. The use of surgical and positioning splint, which play a role of guide for correct bone fragments reposition, has become absolutely indispensable in such surgeries [7]. Nevertheless, the process of jaws positioning at all three planes remains difficult to control within intraoperative conditions and there is always a risk of fragments fixation in the incorrect position [8]. Usually, usage of traditionally designed splint leads to the orientation of the midline based just on visual control, which inevitably associated with some level of maxilla deviation. It was proposed to design splint with mutually perpendicular planes in its’ frontal part at the specialized software. Such approach helps to align vertical plane of the splint with the midline vertical facial plane, while horizontal component could be aligned with the horizontal one accordingly. Proposed approach was approbated in five different clinical cases of facial asymmetry treated by orthognathic surgery. In all analyzed cases dental midline aligned perfectly with the planned one, in two cases the midline sagittal plane deviations (from ANS to PNS) resulted to be less than 2°. The horizontal occlusal plane deviations were considered clinically non-significant. Modification of the surgical splint for jaws positioning in orthognathic surgery treatment enables possibilities to check and control position of maxilla regarding reference facial planes intraoperatively, which in turn increases the accuracy of bone fragments placement and assure high precision of orthognathic surgery for asymmetric cases.

Abstract

Present short communication demonstrates innovative approach for surgical and positioning splint modification, which could improve accuracy of orthognathic surgery during facial asymmetry treatment. Usage of traditionally designed splint leads to the orientation of the midline based just on visual control, which inevitably associated with some level of maxilla deviation. It was proposed to design splint with mutually perpendicular planes in its’ frontal part at the specialized software. Such approach helps to align vertical plane of the splint with the midline vertical facial plane, while horizontal component could be aligned with the horizontal one accordingly. Proposed approach was approbated in five different clinical cases of facial asymmetry treated by orthognathic surgery. In all analyzed cases dental midline aligned perfectly with the planned one, in two cases the midline sagittal plane deviations (from ANS to PNS) resulted to be less than 2°. The horizontal occlusal plane deviations were considered clinically non-significant. Modification of the surgical splint for jaws positioning in orthognathic surgery treatment enables possibilities to check and control position of maxilla regarding reference facial planes intraoperatively, which in turn increases the accuracy of bone fragments placement and assure high precision of orthognathic surgery for asymmetric cases.

Keywords:
- surgical splint, facial asymmetry, orthognathic surgery, digital design
Figure 1. Traditionally designed surgical splint doesn't provide enough possibilities to control the position of jaw intraoperatively considering reference planes.

Figure 2. Different cases of facial asymmetry.
Mutually perpendicular planes in the frontal part of the splint were designed within the 3-matic software (Materialise, Leuven, Belgium). Usage of the mentioned software helped to align vertical plane of the splint with the midline vertical facial plane, while horizontal component was aligned with the horizontal one accordingly (Figure 3). Modeled modified splints with mutually perpendicular planes were produced by the 3D printer Objet30 OrthoDesk (Stratasys Ltd, Waltham, MA, USA) (Figure 4).

Figure 3. Virtual design of modification of the surgical and positioning splint for orthognathic case of facial asymmetry: two mutually perpendicular planes in the frontal part were modeled

Figure 4. The biological models of jaws and surgical splint with mutually perpendicular planes were produced by 3D printing

Figure 5. Intraoperative photographs of facial marker lines and positioning due to the surgical splint references
Five patients with skeletal asymmetry of different etiology were operated. During virtual surgery planning mutually perpendicular planes were modeled at the frontal surface of the splint and aligned with corresponding facial planes. Such approach helped to put the jaws into the correct position according to sagittal and horizontal planes. In each case the marking lines were drawn before the operation according to reference facial planes, which helped to position the splint followed by the upper jaw positioning (Figure 5). Post-operational period passed without any complications (Figure 6).

CBCT images were taken for all patients 3-6 months following the operation. The method of 3D superimposition was used to align post-operational CBCT images with the treatment planning model (formed on the pre-operational CBCT) to evaluate results and check conformity levels (Figure 7).

**Figure 6.** Post-operational photographs: a) intraoperative; b) first day after operation; c) 3 months after operation.

**Figure 7.** 3D superimposition of post-operational CBCT model (coral color) with the planning model (indigo color) based on the pre-operational CBCT.
In all analyzed cases the dental midline aligned perfectly with the planned one, however in two cases the midline sagittal plane deviations (from ANS to PNS) resulted to be less than 2°, which is less than 1.7 mm. The horizontal occlusal plane deviations were considered clinically non-significant. Previous systematic review has mentioned that deviations within 2mm/° between post-operative results and virtually planned orthognathic surgery may be interpreted as acceptable and accurate, and such have been achieved in presented clinical cases [9].

Previously it has been shown that splints and patient-specific implants supports correct transfer of virtually planned surgery model into the clinical conditions with analogical level of accuracy [10]. Nevertheless, presented design of surgical splint support correct intraoperative positioning of bone fragments and enhance of intraoperative control, while also helps to minimize deviations of final outcome regarding vertical and horizontal planes. Sometimes for the analogical reasons two splints technique may be used, but previous study demonstrated that one-splint and two-splint approaches characterized with the analogical patient-centered outcomes [11].

Even though in present study splint was produced by additive technology, but some findings suggest that subtractive CAD-CAM techniques may be more reliable while reaching higher trueness of manufactured splint during personalized orthognathic surgical approach [12].

Orthognathic surgery as any other medical discipline would benefit from implementing some artificial intelligence instruments into daily practice, especially within surgical planning stage, after assuring that proposed AI-model will work in proper manner [13, 14]. Present research further will be continued and in the nearest future will be aimed at developing AI-model, which could design splint in semi-automated manner considering obligatory alignment of splint frontal marker with facial vertical and horizontal planes.

Recent advances within orthognathic surgery would further enhance individualization of treatment pattern, which in turn will help to obtain better patient-centered outcomes. Modification of the surgical splint for jaws positioning in orthognathic surgery treatment enables possibilities to check and control position of maxilla regarding reference facial planes intraoperatively, which in turn increases the accuracy of bone fragment placement and assure high precision of orthognathic surgery for asymmetric cases.

Conflict of Interest

Authors do not have any potential conflict of interests that may influence the decision to publish this article.

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References

Модифікація хірургічного позиціонуючого сплінта з метою хірургічного ортогнатичного лікування асиметрії обличчя

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Анотація

У даному короткому повідомленні продемонстровано інноваційний підхід до модифікації дизайн хірургічного позиціонуючого сплінта, що може підвищити точність виконання ортогнатичних втручань під час лікування асиметрії обличчя. Використання сплінта традиційного дизайну призводить до орієнтації середньої лінії лише на основі візуального контролю, що неминуче пов'язане з деяким рівнем відхилення верхньої щелепи. Нами запропоновано у спеціалізованому програмному забезпеченні проводити моделювання сплінта із взаємно перпендикулярними площинами у її фронтальній частині. Такий підхід дозволяє сумістити вертикальну площу шини із середньою вертикальною площею обличчя, а горизонтальний компонент конструкції – відповідно з горизонтальною площею. Запропонований підхід був апробований у п'яти різних клінічних випадках лікування асиметрії обличчя шляхом проведення ортогнатичних хірургічних втручань. У всіх проаналізованих випадках середня лінія зубів ідеально вирівнювалась із запланованою, у двох випадках відхилення середньої сагітальної площини із середньою вертикалною площею відбулося менше 2°. Відхилення горизонтальної площини було інтерпретовано як клінічно незначущі. Модифікація хірургічного сплінта для позиціонування щелепи при ортогнатичному втручанні дозволяє перевірити та контролювати положення верхньої щелепи щодо референтних площин обличчя інтраопераційно, що, в свою чергу, підвищує точність позиціонування кісткових фрагментів та забезпечує високу точність ортогнатичного лікування скелетної асиметрії обличчя.

Заява про конфлікт інтересів
Цим автори підтверджують відсутність зв'язку з будь-якою організацією чи компанією, яка може мати будь-який фінансовий або нефінансовий інтерес до матеріалів дослідження, розглянутих в цій статті.

Заява про фінансування
Не було отримано жодного фінансування для допомоги в підготовці та проведенні цього дослідження, а також для написання цієї статті.

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