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ARTIFICIAL INTELLIGENCE SPLINT IN ORTHOGNATHIC SURGERY: DESIGN AND APPLICATION

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Abstract:

Orthognathic surgery is an important method for correcting skeletal malocclusions, jaw deformities, facial asymmetry, and functional disorders of the maxillofacial region. The accuracy of surgical planning and transfer of the planned jaw position to the operating field is essential for obtaining predictable results. Recent developments in artificial intelligence, three-dimensional imaging, virtual surgical planning, and three-dimensional printing have created new opportunities for improving the precision of orthognathic procedures. An artificial intelligence-assisted splint can be developed by integrating cone-beam computed tomography, digital dental models, and virtual surgical planning. Artificial intelligence can assist in anatomical segmentation, landmark identification, analysis of skeletal relationships, and individualized splint design. This thesis describes the principles of artificial intelligence-assisted splint design and its application in orthognathic surgery.

Keywords: artificial intelligence, orthognathic surgery, surgical splint, virtual surgical planning, three-dimensional imaging, digital dentistry, maxillofacial surgery.

Introduction

Orthognathic surgery is performed to correct skeletal discrepancies that cannot



be adequately treated by orthodontic treatment alone. Skeletal Class II and Class III malocclusions, maxillary and mandibular deformities, vertical skeletal abnormalities, and facial asymmetry are common indications for surgical treatment. The final result depends on accurate diagnosis, appropriate treatment planning, and precise transfer of the planned skeletal movements to the patient during surgery.

Traditional orthognathic planning is based on clinical examination, radiographic analysis, cephalometric measurements, dental models, and manually fabricated surgical splints. Although these methods remain clinically useful, two-dimensional assessment has limitations in complex three-dimensional deformities. Modern digital technologies provide a more detailed representation of the patient's anatomy and allow surgical movements to be planned virtually before the operation.

Cone-beam computed tomography provides three-dimensional information about the craniofacial skeleton. Intraoral scanning provides digital information about the teeth and occlusal surfaces. These datasets can be combined to create an individualized three-dimensional model. Artificial intelligence can assist in processing this information and identifying relevant anatomical structures.

The aim of this thesis is to describe the design and application of an artificial intelligence-assisted splint in orthognathic surgery and to evaluate its potential clinical advantages and limitations.

Materials and Methods

The digital workflow begins with the collection of patient-specific anatomical data. Cone-beam computed tomography is used to obtain a three-dimensional representation of the maxillofacial skeleton. Digital dental models are obtained using an intraoral scanner or by digitizing conventional dental casts. If necessary, three-dimensional facial scanning can also be incorporated to evaluate facial morphology.

The collected datasets are imported into specialized planning software and registered with each other. Artificial intelligence-assisted algorithms can facilitate

segmentation of the maxilla, mandible, teeth, and other anatomical structures. Automated recognition of anatomical landmarks can reduce repetitive manual measurements and facilitate three-dimensional analysis.

After creation of the virtual patient model, the surgical plan is developed. Depending on the patient's deformity, the plan may include maxillary advancement or setback, vertical repositioning, mandibular advancement or setback, rotational correction, or correction of facial asymmetry. The planned movements are evaluated according to occlusion, skeletal relationships, facial proportions, and functional requirements.

The next stage is the design of the surgical splint. The splint is generated according to the patient's individual dental anatomy and planned postoperative occlusion. Artificial intelligence can assist in identifying stable contact areas, detecting possible interference, and optimizing the geometry of the device. The final digital model can then be manufactured using three-dimensional printing.

Before clinical application, the manufactured splint must be examined for dimensional accuracy and proper adaptation. The physical device should correspond to the approved virtual design. This verification is important because errors during scanning, digital registration, design, or manufacturing can influence the accuracy of the surgical procedure.

Application in Orthognathic Surgery

The main purpose of an artificial intelligence-assisted splint is to transfer the virtual surgical plan into the operating field. After the planned osteotomies have been performed, the splint is positioned according to the established surgical protocol. It helps establish the predetermined relationship between the maxilla and mandible. After the desired position is achieved, the jaws are stabilized using appropriate fixation methods.

The technology may be particularly useful in complex cases with severe skeletal discrepancies or facial asymmetry. Three-dimensional planning allows the surgical team to visualize the intended movements before surgery and to use a patient-specific physical guide during the procedure.

An additional advantage is improved communication between specialists. Surgeons, orthodontists, and dental technicians can work with the same digital model and evaluate the proposed treatment plan before manufacturing the splint. Potential errors or inconsistencies can therefore be identified before surgery.

Artificial intelligence can also support postoperative evaluation. Postoperative three-dimensional imaging can be compared with the original virtual surgical plan. This allows the treatment team to evaluate whether the planned skeletal movements were achieved and to identify possible discrepancies.

Advantages and Limitations

The main advantage of artificial intelligence-assisted splint technology is the integration of several sources of patient information into a single three-dimensional planning system. This allows the surgical team to evaluate skeletal and dental relationships more comprehensively than with conventional two-dimensional methods.

Another potential advantage is improved consistency between virtual planning and intraoperative execution. Because the splint is created from the approved digital plan, it provides a physical reference for achieving the intended jaw relationship.

Artificial intelligence may also reduce repetitive manual procedures. Automated segmentation and landmark identification can facilitate the work of clinicians and decrease the time required for some planning tasks. Digital files can be stored and reproduced, providing a permanent record of the planned treatment.

However, several limitations must be considered. The accuracy of the final splint depends on the quality of the original imaging and scanning data. Errors in

image acquisition, segmentation, registration, virtual planning, or three-dimensional printing may affect the final result.

Artificial intelligence algorithms may also produce errors in patients with severe deformities, missing teeth, previous surgery, or unusual anatomical characteristics. Therefore, automated results must always be reviewed by qualified specialists. Artificial intelligence should support clinical decision-making rather than replace the surgeon's professional judgment.

Discussion

The integration of artificial intelligence into orthognathic surgery represents an important development in digital maxillofacial treatment. The combination of three-dimensional imaging, virtual surgical planning, artificial intelligence, computer-aided design, and three-dimensional printing creates a continuous digital workflow from diagnosis to surgical application.

The artificial intelligence-assisted splint provides a direct connection between the virtual treatment plan and the actual surgical procedure. It can help reproduce the planned jaw relationship and may improve the consistency of intraoperative positioning.

Nevertheless, successful application requires quality control at every stage. Accurate imaging, correct digital registration, reliable artificial intelligence analysis, precise splint manufacturing, and careful intraoperative application are all necessary. The surgeon remains responsible for evaluating the patient's individual anatomy and confirming the final treatment plan.

Future developments may allow artificial intelligence to assist with more advanced treatment simulation and prediction of postoperative skeletal and soft-tissue changes. Machine-learning systems may analyze large numbers of previous cases and provide additional information for individualized surgical planning. However, such applications require clinical validation and careful assessment of safety and reliability.

Conclusion

Artificial intelligence-assisted splints are a promising application of digital technology in orthognathic surgery. Their development combines three-dimensional imaging, digital dental models, virtual surgical planning, artificial intelligence, and three-dimensional manufacturing to produce individualized surgical guides.

The technology can improve the connection between virtual planning and intraoperative jaw positioning, facilitate multidisciplinary communication, and reduce some repetitive planning procedures. At the same time, its effectiveness depends on accurate digital data, reliable algorithms, precise manufacturing, and professional clinical supervision.

Artificial intelligence should therefore be considered a supportive tool in modern orthognathic surgery. Further clinical research is required to determine its accuracy, safety, cost-effectiveness, and long-term clinical value.

References

1. Proffit W.R., Fields H.W., Sarver D.M. Contemporary Orthodontics. Elsevier.
2. Swennen G.R.J., Mollemans W., Schutyser F. Three-dimensional treatment planning of orthognathic surgery. World Journal of Orthodontics.
3. Bell R.B. Computer planning and intraoperative navigation in orthognathic surgery. Journal of Oral and Maxillofacial Surgery.
4. Zinser M.J., Mischkowski R.A., Sailer H.F. Computer-assisted orthognathic surgery and three-dimensional treatment planning.
5. Marchetti C., Bianchi A., Bassi M., et al. Three-dimensional planning and computer-assisted surgery in orthognathic treatment.