Advent of Artificial Intelligence in Orthognathic Surgery: Advancements and Challenges

Anju Sharma,1 Ginpreet Kaur,1 Hardeep Singh Tuli,2 Raunak Singh Chhabra,3 Rashmi Rana4

Abstract

Orthognathic surgery is a procedure used to correct facial deformities and jaw bone misalignment. The use of technology, specifically virtual surgical planning (VSP), has become increasingly prevalent in preoperative planning for orthognathic surgery. High-resolution computed tomography (CT) imaging has enabled computer-aided modelling. Artificial intelligence (AI) implementation has transformed orthognathic surgery methodology. This article highlights the latest market trends and modern-day advancements in the field, including the conventional and surgery first approach for orthognathic surgery. The use of computer-aided surgical simulation (CASS) in VSP for orthognathic surgery was studied. The different software used for orthognathic surgical planning and the detailed protocol followed during the surgery, including the preoperative procedure were discussed along with utilisation of 3-dimension cone-beam computed tomography (3D CBCT) images for surgical planning. The implementation of VSP with CASS had significantly enhanced the accuracy and efficiency of orthognathic surgery for dentofacial deformity correction. The use of technology allowed improved preoperative planning, resulting in better outcomes for patients. The study of different software for orthognathic surgical planning and the protocol followed during surgery has provided valuable insight into the surgery. The continued advancement of technology in orthognathic surgery is promising for the field and for the patients.

Key words: Artificial intelligence; Machine learning; Deep learning; Surgery-first approach; Computer aided design and manufacturing; Surgical system and cone beam computed tomography; Computer aided surgical simulation.

Introduction

This review highlights the implications of artificial intelligence (AI) techniques integrated with orthognathic surgery. Various software is available for virtual surgical planning and challenges and complications associated with orthognathic surgery.

"AI is a broad transdisciplinary field, it is a branch of science and engineering that deals with machine understanding and is typically referred to as intelligent behaviour, with the creation of artifacts".1, 2 It is a discipline in computer science that aims to understand and create intelligent entities, which are often manifested as software programs.3 The use of AI to complete activities that traditionally require human intelligence is transforming numerous industries.3, 4 Their capacity to identify meaningful associations in data
Orthognathic surgical treatment

Surgery requires precise planning to achieve the appropriate stability and harmony. In order to treat obstructive sleep apnoea (OSA), malocclusion and issues with the facial profile, orthognathic surgery is frequently used in craniofacial surgery. The focus of orthognathic surgery is repositioning the maxilla, mandible and chin. It not only enhances fundamental abilities like chewing, speaking and swallowing, but it also forms a component of a comprehensive plan of care for improving quality of life.

Approaches for early orthognathic surgery

Conventional approach

It is known as the orthodontic first approach. Orthognathic surgery traditionally requires significant pre-operative and post-operative orthodontics to achieve significant dentofacial correction. Before undergoing orthognathic surgery, patients receive preoperative orthodontic therapy to reveal the actual skeletal discrepancies and align the maxilla and mandible for a stable surgical occlusion, thereby preventing postoperative occlusal instability. Despite these advantages, preoperative orthodontic treatment comes with

Orthognathic surgical treatment

Surgery requires precise planning to achieve the appropriate stability and harmony. In order to treat obstructive sleep apnoea (OSA), malocclusion and issues with the facial profile, orthognathic surgery is frequently used in craniofacial surgery. The focus of orthognathic surgery is repositioning the maxilla, mandible and chin. It not only enhances fundamental abilities like chewing, speaking and swallowing, but it also forms a component of a comprehensive plan of care for improving quality of life.
notable drawbacks, leading to considerable inconvenience for patients. Dental decompensation involves a gradual decline in the facial cosmetic profile and dental function during the preoperative period. Preoperative orthodontic treatment’s biggest weakness is that it takes a long time to complete; depending on how complicated the patient’s initial dental condition was, to begin with, it can even take up to 48 months.\(^\text{13}\)

**Surgery-first approach (SFA)**

Also referred to as the “surgery-first-orthognathic-approach (SFOA)”. The term “surgery-first approach” refers to a course of therapy that begins with orthognathic surgery and ends with postoperative orthodontics without first undergoing preoperative orthodontics. SFOA may be enforced using 2 methods: the surgical driven approach and also the orthodontic driven approach. In the first method, surgical correction is used to treat both dental and jaw abnormalities. The latter method involves surgically correcting jaw distortion and using orthodontics to cure dental deformity. The modified-surgery technique is used when preoperative orthodontic therapy lasts for less than six months.\(^\text{13, 16}\) The reduced treatment duration has been a key factor in the prevalence of surgery-first orthognathic;\(^\text{17}\) another advantage is the improvement in facial profile right away from starting of the treatment, high levels of patient and orthodontist satisfaction are related to better cooperation during postoperative orthodontics and quick patient recovery.\(^\text{18}\)

While the orthodontics-first approach suggests that orthodontic therapy begins first, followed by orthognathic surgery, the surgery-first strategy states that orthognathic surgery begins first.\(^\text{19}\) Orthodontics alone can address minor dentoskeletal discrepancies, but for more severe and significant disparities, a combination of orthodontic treatment and orthognathic surgery becomes essential for effective and comprehensive management. Orthognathic surgery can be performed as a single-jaw therapy in which just the maxilla or the mandible is operated on, but bimaxillary (or double-jaw) orthognathic surgery must be planned when the diagnostic information and presurgical planning indicate that both jaws need to be osteotomised.\(^\text{20, 21}\)

**Surgical planning by virtual surgery technology with its opportunities**

A method of merging “computer-aided design (CAD)” and “computer-aided manufacture (CAM)” in surgical treatment planning is known as virtual surgery, also referred to as computer-aided surgery. \(^\text{22}\) AI empowers surgeons to optimise skeletal alignments, strategize surgeries for both soft and hard tissues and visualise and evaluate three-dimensional (3D) images of soft tissue and skeletal structures. It also allows surgeons to communicate the virtual plan to patients before the procedure.\(^\text{22}\) The science of virtual reality involves building an artificial environment to evaluate different body parts’ anatomical regions. This can be useful for diagnosis, planning and surgical training.\(^\text{23}\)

Virtual surgery typically comprises four stages. Phase 1 is the data collection it includes radiographic examinations and CT scans, as well as clinical examinations with bite registrations and anthropometric measurements. Phase 2 is the planning phase that involves transferring 3D cone beam computed tomography (CBCT) data into specialised planning software. Phase 3 is the surgical phase, it involves translating the digital surgical plan to the patient using stereolithographic models, occlusal splints, cutting guides, and intraoperative navigation. Phase 4 the assessment phase, involves employing intraoperative or postoperative CT imaging to assess the precision of virtual surgical plan transfer.\(^\text{22}\) By improving the depiction of 3D phenotypic changes, virtual surgical planning has made it easier to make precise diagnoses and thorough treatment plans. Due to these benefits, intraoperative osteotomies and fixation have increased osteotomy accuracy and considerably reduced preoperative surgical planning.\(^\text{13}\) CBCT scan is preferred for 3D scan, CBCT is a method for acquiring medical images and a cone-shaped X-ray beam is focused on a two-dimensional (2D) detector. Two CBCT scans were collected using the “i-CATTM equipment, version 17-19 (Imaging Sciences International, Hatfield, PA, USA)” one preoperative (taken two months before orthognathic surgery) and one postoperative (taken one month after surgery).\(^\text{24}\)

Orthognathic surgery falls under the scope of oral and maxillofacial surgery and orthodontics that tries to correct dentofacial defects by moving the maxillomandibular complex into a more functional, balanced and aesthetically acceptable posture. Because of the procedure’s complexity, the accuracy of surgical planning is essential. The adoption of 3D virtual planning techniques and the creation of prototyped splints are made...
possible by developments in imaging, planning software and prototyping technology. In order to better understand the link between the dental arches and the surrounding bones, virtual surgical planning (VSP) provides new opportunities. When compared to traditional surgical planning, this method offers several benefits, including the ability to visualise deformities and asymmetries that are occasionally missed, the freedom to simulate various surgical procedures to achieve the best possible patient outcomes, the ability to identify potential complications and simplicity in assessing and adjusting the centric relation in the temporomandibular joint. 25 At the end of the 1980s, 3D virtual planning software packages with virtual operating rooms (VOR) were introduced. Significant advancements in these software modules have been made possible by the IT revolution (2000s). The doctor can document, analyse and plan orthognathic surgery using a face skeleton model due to the reconstruction of “digital imaging and communications in medicine (DICOM)” files in a VOR. Dental models and software to analyse the soft tissue surface of the face's soft tissues were also introduced. 26 A pre-intervention survey is performed to evaluate training requirements and a post-intervention feedback survey to assess the system’s effectiveness, usability and acceptability was utilised to assess the validity of VR surgery. 27 Because of technological advances, particularly 3D printing and VSP, this field has grown and improved significantly. The advancement has significantly enhanced preoperative preparation, leading to a more streamlined journey from pre-surgery to post-surgery. While patients might incur extra expenses, the benefits include reduced operative duration and shorter hospitalisation periods. Future research could concentrate on a cost-benefit analysis to determine whether virtual planning reduces total health-care costs. 7 VSP has proven to be accurate and results in better clinical outcomes as compared to the traditional model surgery. 28 Both the traditional and the new 3D virtual method operate on the same principles. The objective remains to provide the greatest possible outcome for improved patient care. 29

Implementation of AI software in orthognathic surgical planning

The surgical approach employed and the precision with which the surgical plan is carried out determine how well an orthognathic procedure goes. Two crucial and fast developing topics of study are virtual planning and computer-assisted surgery. Computer-assisted surgery (CAS) is the practise of performing or planning surgery with the aid of cutting-edge technology. The use of software analysis, virtual planning, sophisticated imaging fast prototyping technologies, robotics and image guiding systems are some examples of these techniques. 30 Hirsch first made CAS for mandibular reconstruction available in 2009. Since then, it has become more and more popular. The terms fast prototyping “computer-aided design” and “computer-aided manufacturing” are also used to describe it. 31 For orthognathic (jaw realignment) and temporomandibular joint (TMJ) surgery, facial trauma, implantology (dental implants) and maxillomandibular reconstruction, craniofacial surgery (CMF) and dentistry currently use CAS most frequently. 32 After a model operation is designed, the production of surgical splints on dental casts is the most common method for transferring the desired new relationship of the jaws. 33 There are a variety of software programmes for CAS and some of them enable internal CAS to be carried out using database images (CBCT, intraoral scans) and with the creation of a surgical splint it is then transferred to the operating room. 34 Few software available for planning of orthognathic surgery are enlisted in Table 1, which include the Dolphin imaging (version 11.9, California, USA), 35-37 Dolphin imaging (11.95, USA), 38 Proplan CMF (Leuven, Belgium), 35, 39-42 Proplan CMF (Materialise CMF, USA), 43 ITK-SNAP (3.4.0, USA), 35, 44 Dentofacial Planner Plus (USA), 36, 43, 46-49 SurgiCase (5.0, Belgium), 49 SurgiCase-CMF PRO 1.2 (USA), 50 3-matic (Belgium), 50-52 3D Slicer (4.5.0-1, USA), 43, 44, 53 OrthognathicAnalysyer (2.0), 54, 55 Maxilim (Belgium), 55, 59, 57, 58 IPS CaseDesigner (2.0.4.2, Germany), 59, 59 VRMesh (USA), 59, 60 Nemo-Fab (Spain) 60, 61 and Autodesk MeshMixer (USA). 35, 61 Dolphin 3D imaging software helps to enable CBCT volumes to be oriented and selectively cropped and allows linear measurements of the joint space and volumetric analysis of changes in condylar volume. 62, 63 The “Houston Methodist Research Institute’s Surgical Planning Laboratory” has created a computer aided surgical simulation (CASS) protocol tailored specifically for orthognathic surgery. The CASS protocol is discussed below in detail. There is a modified CASS method that uses extraoral photographs in the natural head position (NHP) taken with a camera’s built-in gyroscope to achieve the same accuracy as the regular CASS method. 65
CBCT images were taken prior and post orthognathic surgery for the assessment of mandibular anatomy and position. CBCT images have revolutionised orthodontics by computer-aided surgical simulations and has been adapted for use in orthognathic surgery to make cephalometric analysis, surgical simulation and splint fabrication easier.\textsuperscript{64, 66} CBCT scanners produce high-resolu-

<table>
<thead>
<tr>
<th>Software</th>
<th>Version</th>
<th>Country</th>
<th>Data</th>
<th>Statistical analysis</th>
<th>Application</th>
<th>Ref.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proplan CMF</td>
<td>-</td>
<td>Belgium</td>
<td>Each patient had cone-beam CT scanning and using STL format the scanned data is imported into the software.</td>
<td>Paired t-test</td>
<td>Generate 2D or 3D visualisations, preoperative testing, analyse postoperative results and refine surgical plans.</td>
<td>35, 39-43</td>
</tr>
<tr>
<td>Dentofacial Planner Plus</td>
<td>-</td>
<td>USA</td>
<td>Compared with CBCT scan of initial one of the patients.</td>
<td>Chi-square test, ANOVA and the Tukey test</td>
<td>Profile analysis, treatment prediction and predict the postsurgical profiles.</td>
<td>36, 37, 46-48</td>
</tr>
<tr>
<td>Dolphin Imaging</td>
<td>11.9</td>
<td>USA</td>
<td>It uses an algorithm based on sparse landmarks to predict soft tissue outcomes, offering the flexibility to adjust hard-to-soft tissue ratios to accommodate variations among different patients.</td>
<td>Friedman test</td>
<td>Predict the postsurgical profiles and changes with a primary focus on the 2D midline and upper lip.</td>
<td>35-37</td>
</tr>
<tr>
<td></td>
<td>11.95</td>
<td>USA</td>
<td>Lateral cephalograms, horizontal measurement, vertical measurement and 3 angular measurements of the patients was analysed.</td>
<td>Student’s t-test</td>
<td>Assessing skeletal changes post orthognathic surgery.</td>
<td>38</td>
</tr>
<tr>
<td>Surgi Case</td>
<td>5</td>
<td>Belgium</td>
<td>CAS was performed on patients with an average age of 35.5 years and CT of the maxillofacial skeleton and lower extremities were performed.</td>
<td>-</td>
<td>Evaluation of orthognathic surgical outcomes and accuracy</td>
<td>49</td>
</tr>
<tr>
<td></td>
<td>CMF PRO 1.2</td>
<td>USA</td>
<td>Preoperative multi-slice imaging data were acquired using a CT unit, stored in DICOM format. It uses a physically based, previously published simulation module.</td>
<td>M, SD, SE, Max, 90th and 95th percentile</td>
<td>Used to calculate postoperative simulation of the soft tissue and helps to simulate any movement.</td>
<td>50</td>
</tr>
<tr>
<td>3-matic</td>
<td>-</td>
<td>Belgium</td>
<td>Data is collected through CBCT scan of patients, the software allows for various analyses and simulations on the patient’s 3D models.</td>
<td>Student’s t-test</td>
<td>This software serves as a preprocessing tool, enabling users to perform tasks such as repairing, preparing geometry, remeshing and making design modifications directly on the mesh data.</td>
<td>50-52</td>
</tr>
<tr>
<td>ITK-SNAP</td>
<td>3.4.0</td>
<td>USA</td>
<td>Before the surgical procedure, all the participants underwent preoperative scanning for virtual surgical planning and follow-up scans were performed one week later.</td>
<td>STATA 14.2</td>
<td>This tool is utilised for the segmentation of structures in three-dimensional (3D) and four-dimensional (4D) biomedical images.</td>
<td>44, 45</td>
</tr>
<tr>
<td>3D Slicer</td>
<td>4.5.0-1</td>
<td>USA</td>
<td>CBCT scan of patients.</td>
<td>STATA 14.2</td>
<td>The software is designed for visualising, processing, segmenting, registering and analysing medical, biomedical and other 3D images and meshes. Additionally, it facilitates the planning and navigation of image-guided procedures.</td>
<td>45, 53, 54</td>
</tr>
</tbody>
</table>
Using six confirmed cephalometric landmarks, the 3D augmented virtual head model was placed in its anatomically natural position before the surgery. IBM SPSS software was used to analyze and improve 3D planning accuracy in bimaxillary surgery.

**Maxilim**
- Belgium, CBCT scan of patients.
- CBCT scan of patients.
- IBM SPSS software
- This tool is employed to create a 3D virtual head model with augmented features.

**IPS Case Designer**
- 2.0.4.2, Germany
- The models are scanned using an intraoral scanner and then imported into VRMesh in the stereolithography (.stl) format.
- Real-time soft tissue simulation, 3D Cephalometric analysis.
- t-test
- Student t-test

**VRMesh**
- USA
- The models are scanned using an intraoral scanner and then imported into VRMesh in the stereolithography (.stl) format.
- One-sample Student t-test
- Used to evaluate the real-time quality of the occlusions.

**NemoFab**
- Spain
- CBCT scan of patients.
- Surgical planning software.

**Autodesk Mesh-Mixer**
- USA
- CBCT scan of patients.
- Enables the surgeon to precisely analyze and strategize the surgical procedure and is capable of performing Boolean operations.

ANOVA: analysis of variance; M: mean; SD: standard deviation; SE: standard error of mean; CBCT: cone beam computed tomography; CAS: computer-assisted surgery; DICOM: digital imaging and communications in medicine; Ref.: reference number;

**CASS protocol**

Through the use of CASS software, orthognathic surgery’s effectiveness and precision in treating dentofacial deformity have been greatly increased. CASS clinical implementation entails the following four steps: 1) gathering preoperative information, 2) data processing, 3) surgical planning and 4) plan execution itself. Typically, a surgeon handles the first and third processes; however, the other two might be delegated to a specialist or an independent service provider.

**Preoperative data collection**

Preoperative data are acquired in this stage during an hour-long session. Eight steps make up this appointment: (1) taking dental impressions; (2) bite-jig fabrication; a patient-specific bite-jig is created by adapting a stock jig frame to fit the patient’s teeth. The number of impressions required for the planning process depends on the type of surgery (Figure 1). Until the fabric is cured, the jig is maintained in place between the patient’s teeth. This bite registration should be taken in centric relation (Figure 2). (3) Clinical measures are taken and the measurements required for clinical planning are noted. The following are some examples: (a) “rest-incisal-show” and “smile-dentogingival-show”, which are used to determine the maxilla’s vertical position; (b) dental midpoint (midline) deviations, which are used to determine the position of the transverse jaw; and (4) clinical photography, in which the patient’s face and teeth are captured on camera. Facial images should be shot with the patient in the NHP position and a plumb line in the backdrop so that the proper alignment of the face may be confirmed afterwards. (5) Recording the patient’s surgical planning, which is necessary for the creation of an anatomical reference frame. The goal of these photographs is to confirm that the virtual head model is correctly oriented for planning. A bite-jig is put between the patient’s teeth and has a sensor attached to it. It is requested that the patient stand straight and place their head in NHP. Lastly, while in this position, the sensor’s pitch, roll and yaw
are recorded; (6) confirming that the models and the bite-jig are accurate by testing the fit of the stone dental models on the bite-jig, which is done by a surgeon or an assistant; (7) after obtaining a CT scan, or ideally a CBCT scan, the patient is fastened to the bite-jig, which is then attached to the fiducial registration face-bow. The patient is told to maintain relaxation in his or her facial soft tissues while being scanned.\(^7\)

**Data processing**

The procedure may be carried out by the surgeon, a third-party service provider, or a member of the clinic or institution who is knowledgeable about CASS planning. The procedures for processing data consist of; (1) construction of a virtual model of a composite head - the first stage is to create a model that accurately depicts the teeth, soft tissues and skeleton. The midface model, soft tissue model, mandibular model and fiducial marker model are four distinct and correlated 3D-CT models that are created. (2) Using the fiducial face-bow as a reference, an anatomical reference frame is created for the head model and the NHP of the computer model is created by utilising the recorded roll, pitch and yaw to the face-bow frame. (3) Digitisation of all cephalometric landmarks and completing a cephalometric analysis are regarded to be essential diagnostic procedures for identifying the most effective therapy approach.\(^5\) Any sort of cephalometric analysis can be requested by the surgeon, but he or she should be aware that 3D cephalometry is significantly more complicated than 2D cephalometry. (4) Creating the virtual osteotomies - carry out virtual genioplasty, Le Fort I osteotomies and mandibular ramus osteotomies eg; establishing the final occlusion. (5) The final occlusion that the surgeon chose is etched on the stone dental models. This stone models are initially converted into the final occlusion using the surgeon’s generated bite registration. The models are then all simultaneously scanned with either a high-resolution optical surface scanner or a CBCT scanner. After segmenting the scan, a 3D image of the upper and lower teeth in their final occlusion is produced. The “final-occlusal-template,” as the produced image is known, is loaded into the planning tool and used as a guide to articulate the jaws in final occlusion. Positioned in line with the upper teeth of the “Le Fort I” segment are the upper teeth of the final occlusal template. After that, the distal mandibular segment is adjusted so that the lower teeth line up with those of the template. The template can be aligned to one jaw, then the other jaw to the template because the template’s upper and lower teeth are in final occlusion. This will automatically align both jaws into final occlusion.\(^72, 73\)

**Surgical planning**

Using CASS software, this is accomplished on a computer. A surgeon can complete the process alone or with the help of a planning professional familiar with the programme (Figure 3). To make sure that the data processing is accurate, the planning process starts with a checklist. The following items are included on the checklist: (1) Is the anatomical reference frame defined correctly? (2) Have all of the cephalometric landmarks been accurately digitalised? (3) Are all virtual
osteotomies correct? (4) Is the final occlusion accurate? Even when mandibular surgery is performed initially, the maxilla should always be the first part of the CASS planning for any double-jaw surgery. This is because the surgeon is more confident where the maxilla should be positioned than the mandible.\textsuperscript{72}

The first step in correcting maxillary abnormalities is to verify the alignment of the teeth symmetrically with respect to the midsagittal plane. Three transformations are necessary for symmetric alignment, including normalising transverse position. The maxillary incisal midpoint is transversely translated onto the midsagittal plane, normalising roll. (1) Roll rotation pivots the maxilla around the incisal midpoint, normalising yaw rotation, which pivots the maxilla around the incisal midpoint. (2) Normalisation of vertical position: The maxilla's vertical position is adjusted. The planner adjusts the maxilla forward or downward to place the incisal midpoint optimally in relation to the upper lip stomion. (3) Pitch normalisation - maxillary pitch is adjusted. The planner adjusts the maxilla's pitch by rotating it around the incisal halfway. Maxillary pitch rotation affects the size of the airway, the projection of the anterior nasal spine, the projection of the chin, the inclination of the maxillary central incisors and the inclination of the maxillary occlusal plane. All of these factors must be taken into account when determining the best maxillary pitch for a particular patient. (4) By aligning the maxilla in anteroposterior position, the anteroposterior position is normalised. This correction is performed last since earlier changes could have an impact on how far the maxilla is advanced.\textsuperscript{72}

Additionally, it involves aligning the proximal regions of the jaw and correcting mandibular abnormalities, rotation of each proximal segment about the axis of its condyle to align it.\textsuperscript{72} Then, chin deformities must be corrected. This assessment is crucial because the movement of the mandibular distal segment changes the position of the chin. Planning progresses to the last phase. In both cases, the planner should execute a genioplasty by changing the chin piece until the outcomes are satisfied, depending on whether the chin is normal or incorrect.\textsuperscript{72}

Finally, with the aid of the planner, the residual final symmetry is examined. In improperly symmetric mandibles, symmetry is preserved by putting the distal mandible in final occlusion. The patient's intrinsic mandibular asymmetry could not be fixed even after the distal jaw is brought into final occlusion. Finishing a final symmetry assessment on every patient is crucial since low to moderate degrees of inherent asymmetry could not be obvious to the eye.\textsuperscript{72}

Preparation for plan execution
Preparation of the tools required at the time of the surgery for transferring the computerised surgical plan to the patient is the last step of the CASS protocol. Usually, a third-party service provider is hired to handle this. The tables and graphics that show the intended movements, including mapped areas of collision, are created and displayed during surgery to direct the procedure.\textsuperscript{72}

The implementation of VSP with CASS has significantly enhanced the accuracy and efficiency of orthognathic surgery for dentofacial deformity correction. The use of technology has allowed for improved preoperative planning, resulting in better outcomes for patients.

Challenges encountered during surgery
Major challenges faced during orthognathic sur-
Early orthognathic surgery involves the conventional approach also called as the orthognathic first approach and the surgery first approach. In contrast to the orthodontics-first strategy, which means that the orthodontic treatment comes first, the “surgery-first approach” implies that the orthognathic surgery comes first. Virtual surgery, also known as “computer-aided surgery”, is a technique that combines CAD and CAM into surgical treatment planning. Virtual surgery involves 4 phases data collection, planning, surgical and assessment. By improving the depiction of 3D phenotypic changes, virtual surgical planning has made it easier to make precise diagnosis and thorough treatment plans. CBCT images should be taken prior and at the end orthognathic surgery for the assessment of mandibular anatomy and position. In order to assess the complex dentofacial structures, 3D CBCTs are the preferred technique. CASS is clinically implemented in 4 steps: collection of preoperative records, data processing, surgical planning and preparing for plan execution. Basic steps are: first the facial photographs are taken with patient in the NHP, creation of virtual model, 3D cephalometry, correction of maxillary, mandibular and chin deformities and transferring the computerised surgical plan to the patient. Patient age and the psychological and/or psychiatric difficulties can be the challenge for surgery. Other challenge is it requires a personal computer workstation with good graphic ability. Haemorrhage and bad split/segment fractures are the various intraoperative complications associated during surgery. To overcome the challenges of early orthognathic surgery and for effective planning of surgery different software are being employed such as Proplan CMF, Dolphin Imaging, SurgiCase, 3-matic, ITK-SNAP, OrthoGnathicAnalyser etc. Use of digital tools will have an immense impact on orthognathic-surgical

Orthognathic surgery-related complications

Despite the fact that the majority of patients undergo orthognathic surgery for cosmetic reasons, postoperative functional issues are more frequently experienced after cosmetic changes. Patients must therefore carefully consider whether having orthognathic surgery will serve an aesthetic or functional goal. The 3D soft tissue alterations after orthognathic surgery have piqued the curiosity of doctors and patients alike. Orthognathic surgery can result in a wide range of problems. Intraoperative complications include haemorrhage and bad split/segment fractures. When the “inferior alveolar, superior alveolar, maxillary, retromandibular, facial and sublingual vessels” are injured, it might result in severe bleeding. Bad split/segment fractures, like buccal plate fracture, “distal segment lingual fracture” can occur. As the population ages and medical

Conclusion

Early orthognathic surgery involves the conventional approach also called as the orthognathic first approach and the surgery first approach. In contrast to the orthodontics-first strategy, which means that the orthodontic treatment comes first, the “surgery-first approach” implies that the orthognathic surgery comes first. Virtual surgery, also known as “computer-aided surgery”, is a technique that combines CAD and CAM into surgical treatment planning. Virtual surgery involves 4 phases data collection, planning, surgical and assessment. By improving the depiction of 3D phenotypic changes, virtual surgical planning has made it easier to make precise diagnosis and thorough treatment plans. CBCT images should be taken prior and at the end orthognathic surgery for the assessment of mandibular anatomy and position. In order to assess the complex dentofacial structures, 3D CBCTs are the preferred technique. CASS is clinically implemented in 4 steps: collection of preoperative records, data processing, surgical planning and preparing for plan execution. Basic steps are: first the facial photographs are taken with patient in the NHP, creation of virtual model, 3D cephalometry, correction of maxillary, mandibular and chin deformities and transferring the computerised surgical plan to the patient. Patient age and the psychological and/or psychiatric difficulties can be the challenge for surgery. Other challenge is it requires a personal computer workstation with good graphic ability. Haemorrhage and bad split/segment fractures are the various intraoperative complications associated during surgery. To overcome the challenges of early orthognathic surgery and for effective planning of surgery different software are being employed such as Proplan CMF, Dolphin Imaging, SurgiCase, 3-matic, ITK-SNAP, OrthoGnathicAnalyser etc. Use of digital tools will have an immense impact on orthognathic-surgical
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Funding

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Data access

The data that support the findings of this study are available from the corresponding author upon reasonable individual request.

Author ORCID numbers

Anju Sharma (AS): 0009-0006-9905-0199

Ginpreet Kaur (GK): 0000-0002-5151-914X
Hardeep Singh Tuli (HST): 0000-0003-1155-0094
Raunak Singh Chhabra (RSC): 0009-0000-9145-3264
Rashmi Rana (RR): 0000-0003-1461-9456

Acknowledgement

We are thankful to Shobhaben Pratapbhai Patel School of Pharmacy and Technology Management, SVKM’s NMIMS for providing the facility.

Author contributions

Conceptualisation: AS, GK
Methodology: AS, GK
Investigation: AS, RR, HST, RSC
Writing - original draft: AS, RR, HST, RSC
Writing - review and editing: GK, RSC, HST, RR
Visualisation: AS, GK
Supervision: AS, GK

References


38. Thet PH, Koboosaya B. Reproducibility of computerized cephalometric analysis software compared with conventional manual tracing for analyzing skeletal...


65. Ferraz FWDS, Iwaki-Filho L, Souza-Pinto GN, Iwaki LCV, Li AT, Cardoso MA. A comparative study of the accuracy between two computer-aided surgical simu-


