The Era of Virtual Surgical Planning
University of Washington Orthodontics
September 4th 2020

Abhi K. Banda  D.M.D., M.D.
Diplomate of the American Board of Oral and Maxillofacial Surgery
Bel-Red Oral and Maxillofacial Surgery
Attending Surgeon, Overlake Medical Center and Swedish Medical Center
Affiliate Professor, University of Washington
Bellevue, WA

VTP = VSP

Virtual Treatment Planning
Virtual Surgical Planning

The Era of Virtual Surgical Planning

Applications:
1. Orthognathic Surgery
2. Reconstructive Maxillofacial Surgery
3. Dental Implant Surgery
I have no conflicts of interest to declare.

All photographs in this presentation should not be distributed or reproduced without written permission by Dr. Banda.
Clinical Interests

- Third Molar Surgery
- Intravenous Anesthesia
- Orthodontic exposures, Surgical Anchorage
- Orthognathic Surgery
- Implantology
- Bone Grafting, Sinus lifts, Ileac Crest Grafts
- Trauma Surgery

Orthognathic Surgery

- Single Case Presentation
- The Era of Virtual Surgical Planning
- Post Operative Results
- Complications
- Our Future

Indications for Orthognathic Surgery

- Face
  - Facial and dental esthetics causing problems with interaction

- Airway
  - Medical: Obstructive Sleep Apnea

- Bite
  - Dental: Speech difficulties, eating difficulties

Interview Data

- Gender: Female
- Age: 17
- P/P’s C.C: It’s hard to chew food.
- Med Hx: Denies
- Allergies: NKDA
Frontal Clinical Exam
- Facial Form: Oval
- Transverse Facial Proportions: normal
- Vertical Facial Proportions: long lower third
- Incision-Stomion at rest: full tooth
- Breathing: normal
- Lips: thin

Profile Clinical Exam
- Soft tissue profile: convex
- Nose: flat dorsum, no supratip break
- Nasolabial Angle: obtuse
- Chin: normal LM fold
- Upper Incisor Position: Slight posterior to GALL line

Smile
- Incision-Stomion
- Smiling: full tooth + 7mm gingivae

Intraoral Front
- Teeth present clinically:
  - 7654321 1234567
  - 7654321 1234567
- Overjet: 2 mm
- Overbite: 10%
- Malocclusion: Maxilla and mandible in relation to midsagittal plane is midline. Dental to dental midline is also coincident
- Periodontal Condition/Hygiene: Fair
- Crossbite (3-3/3-3): none

Function
- Maximum Opening: 45mm
- CE-CC Discrepancy: 2-3mm
- Muscles: non-tender
- Habits: none
- Speech: normal
- Tongue: normal
Right Buccal
- Molars: class II
- Canines: class III

Left Buccal
- Molars: class II
- Canines: class III

Problem List

<table>
<thead>
<tr>
<th></th>
<th>Transverse</th>
<th>Sagittal</th>
<th>Vertical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft Tissue</td>
<td>None</td>
<td>Concave Profile</td>
<td>Gummy Smile</td>
</tr>
<tr>
<td>Skeletal</td>
<td>Transverse discrepancy</td>
<td>Maxillary Hypoplasia</td>
<td>Mandibular Hypoplasia</td>
</tr>
<tr>
<td>Dental</td>
<td>Inter-Arch discrepancy</td>
<td>Class 2 malocclusion</td>
<td>none</td>
</tr>
</tbody>
</table>

Other: (Finances, Behavior/Anticipated Cooperation, Perio, etc.)

3rd Molar Extractions
- Ideal Timing
  - 17-19 years old
    - Lower complication rate
  - Root formation >1/2-2/3, or 2/3 to subtotal
  - 6-9 months prior to surgery
  - Remodeling of lingual plate
  - May be removed intraoperatively, however is undesirable
    - Bad Split
    - Bone stock for fixation

THE PERFECT REFERRAL
3rd Molar Extractions
THE PERFECT REFERRAL

Advance 6mm
Impact 5mm
CCW Rotate
BSSO to III
Net anterior mandibular movement
Should be significant
Genioplasty for esthetic balance

Ideal Treatment Plan

Orthognathics:
Maxilla: 3 piece Lefort 1
6mm AP advancement
5mm Impaction at the anterior
Mandible: BSSO
2 degree occlusal Counter Clockwise rotation of the MM complex
Chin: 4 mm genioplasty

VSP: A (Very) Brief History of Time

1840: First US patent for dental articulators
1912: First Single Hinge Articulator: Rieter
1921: Semi-Adjustable Hanau Articulator
1972: CT Scan
1998: CBCT For Dental Use
2006: CAD/CAM used For splint fabrication
2012: First Blinded Randomized Controlled Trial Of VSP
Widespread Acceptance

1848: Hullihen performs first orthognathic surgery
1955: Obwegeser introduces modern osteotomies

Exclusive Use Of VSP As New Normal
3 Phases of Treatment

**Phase I**
- Pre-surgical Ortho/Decompensation 12-24 months
- Goals: Level Align Transverse Expansion Extractions 3rd molars (at least 6 months prior to surgery) Retroclines Invisalign

**Phase II**
- Surgery: 1.5-4 hours
- Recovery: 1-2 weeks downtime
- Follow up: 6 weeks

**Phase III**
- Post-operative Orthodontics 3-6 months
- Goals: Finishing and detailing Deband

Pre-surgical Ortho-Decompensation 12-24 months

**Pre-surgical Workup**
- At least 3 weeks before surgery
- Final impressions and scanning
- CBCT
- Photographs
- Contraindications
- Removal of any removable appliances

Orthodontic Consultation
- Goals: Diagnosis Triage
- Triage
- Understand ideal vs. compromised treatment

Surgical Consultation
- Goals: Determine surgical candidacy
- Understand risks of surgery and recovery
- Diagnosis
- Provisional Treatment Plan

Pre-surgical Ortho-Decompensation 12-24 months

Post-operative Orthodontics 3-6 months

**VSP® Orthognathics Timeline**

**Patient Arch Impressions: Multiple Methods**

- Standard Protocol: Both cut out/stone models with an indication of the final occlusion
- Charlotte Method: CT scan of cut out/stone models and scan of models set in final occlusion
- Intraoral Scanning Protocol: STL files of the patients upper and lower arches

**VSP® Orthognathics Timeline**

**Clinical Data**

- Clinical photos of the patient in natural head position
- Completed order form with specific case information
- CT or CBCT scan of the patient in centric relation with a full FOV

Orthodontist on conference call with Surgeon

9/3/2020
Virtual Surgical Planning: A Brief Overview

Orthognathic Surgery Work Up:
- Patient Interview
- Data Collection:
  - Clinical Measurements
  - Impressions and Models
  - Bite registration done in CR
  - Imaging: Cephalogram, CT scan per VSP Protocol in CR
  - Cephalometric analysis
  - Model Surgery (Not movements)

Virtual Surgical Planning Conference Call:
- Simulate planned osteotomies for intermediate and final splint fabrication
- Discuss splint design
- Simulation of maxillary, mandibular, and chin movements
- Opportunity to make fine adjustments
- Visualize bony gaps and overlaps
- 3D-360 degree views of pre-operative, peri-operative, and post-operative results

Deliverables
CASE REPORT
- Physical and digital PDF of case report includes:
  - Final surgical workup
  - Summary table of cephalometric movements
  - Initial, intermediate, final positions with splints in place
  - Gaps and overlap analyses of all maxillary and mandibular segments
  - Any additional images requested by surgeon

Receipt of Data
When the CT / CBCT scan arrives, the first step is to convert the 2-Dimensional images into 3D representation of the patient's anatomy. Underlying structures such as teeth and inferior alveolar nerve are also created in 3D.

Alignment of Occlusal Scans to Patient Scan
- Anatomy segmented from scan and modeled in 3D
- Arch impressions converted to digital
- Occlusal surfaces from CT/ CBCT scan replaced with surfaces from digital impressions

In-house SLA Manufacturing

Additional Webmeeting Preparation
- Initial Osteotomies
- Cephalometric landmarking
- Initial treatment planning per order form
Articulator

Originally designed to relate maxilla to terminal hinge axis of mandible
Horizontal arm of articulator relates to Frankfort plane
Facebow required to transfer
Reliable estimation of distance between dentition and intercondylar hinge axis

Articulator

Mount maxillary cast using facebow transfer
Correct occlusal plane angle
Use bite registration to mount mandibular cast
Use separate color stone for models and mounting plaster

Articulator

Accurate facebow recording
Accurate reproducible bite registration
Accurate impressions
Semi-adjustable anatomic articulator

Articulator

Advantages
Cost efficient
Appreciation of intra-operative movements
Splint production
Mock surgery

Disadvantages
Many multiple points of potential error from head positioning, centric seating, patient compliance, transfer error, mounting error, model and plaster distortion
Asymmetry of condyle or external auditory canal positions
Improper position of facebow
Relatively isolated dental movements without tangible appreciation of facial skeleton or soft tissues
Time consuming

A Modified Approach to “Model Planning” in Orthognathic Surgery for Patients Without a Reliable Centric Relation
Jeffrey C. Ponsich, DMD, M.O.,* Pat Riola, DMD, M.O., and Feng Yu, DMD

Orthognathic surgery, unlike most surgical procedures, demands precise preoperative dental laboratory fabrication. Thus, the accuracy of the orthodontic treatment plan must be balanced against the precision of the facial and dental evaluation including photographic analysis, imaging studies, and a cephalometric analysis. Preoperative records also include dental impressions and radiographic measurements. The dental models are placed on a simulating articulator for the planned movements, which are then transferred to a physical articulator. The simulating articulators are then standardized to the final coordinate setting.

When performing orthognathic surgery, the introduction of error can occur at many stages. If an inaccurate bite registration is obtained from the patient preoperatively, this will be magnified in the articulator and model, leading to inaccurate surgical guidance and resulting in intraoperative error. Obtaining an accurate and reproducible bite registration is challenging, particularly in the current climate of telemedicine. Since the articulator is an indirect means of determining movement, there are specific clinical settings in which obtaining an accurate and reliable CT can be helpful.

An Evaluation of Face-Bow Transfer for the Planning of Orthognathic Surgery
Christoph Zitzmann, MD, DMD,‡ Bastian Hromatka, MD, DMD,‡ Turan Guldal, MD, DMD,‡ and Peter Buchmüller

Purpose: The purpose of this study was to evaluate the error magnification in the clinical application of facebow devices. The clinical and methodological inaccuracies, as well as deviations from reference planes, were investigated.

Materials and Methods: The present method is based on a 3-dimensional virtual planning procedure for orthognathic surgery. In 15 patients with orthodontic deviations, cone-beam computed tomography images taken from patients with a referenced facebow planning and a centric registration step were matched with cone-beam computed tomography scan images of the planned position of the mandible. The centric registration step was performed using a reference software program with virtual patient models and virtual facebows.

Results: Statistical significance was set at P < .05 and turned by institutes of analysis. The results of the clinical and methodological errors, as well as deviations from reference planes in terms of distances and angles, were measured.

Face bow and articulator for planning orthognathic surgery: I face bow
Fraser Walker,1 Aslam F. Ayub,2 Kithoreed F. Moses,3 Joseph Barbened1

Abstract
Orthognathic surgery that involves movement of the maxilla relative to the skull is usually planned using casts mounted on an articulator. Accurate prediction of the needs of the patient is essential to achieve planning.

Face bow and articulator for planning orthognathic surgery: II face bow
Fraser Walker,1 Aslam F. Ayub2, Kithoreed F. Moses3, Joseph Barbened1

Abstract
Orthognathic surgery that involves movement of the maxilla relative to the skull is usually planned using casts mounted on an articulator. Accurate prediction of the needs of the patient is essential to achieve planning.
Face bow and articulator for planning orthognathic surgery: 2 articulator

Fraser Walker*, Abdul F. Ayub**, Muhammad F. Mazz*, Joseph Baroudi**

* Scottish Dental Regional, Department of Oral and Maxillofacial Surgery, Glasgow, UK
** University Dental Hospital and School, and Oral and Maxillofacial Surgery Department, Glasgow, UK
Accepted 3 February 2009

Abstract

Patients who request orthognathic surgery may have asymmetry in the position of the temporomandibular joints relative to the maxilla, which is inappropriate to correct by occlusal re-alignment and for surgical planning. No devices can safely accommodate these 3D maxillary bone base abnormalities, and previous authors have noted that it is impossible to predict the position of the maxilla accurately. Furthermore, it is impossible to determine the precise amount of movement that will correct for the skeletal asymmetry using the current techniques. The purpose of this study was to assess the effect of different articulators on the bias of planning models and compare the accuracy of planning using a traditional model with that of the new articulator.

Keywords: Orthognathic surgery; Face bow; Articulator.

A Simple and Accurate Method for Mounting Models in Orthognathic Surgery

Larry M. Wolford, DDS* and Atsuto Gakamo, DDS*

Accuracy of analytic model planning in bimaxillary surgery

N. Park, DMD, DDS, MD. Institute of Advanced Orthodontics and Orthognathic Surgery, Seoul, Korea

Purpose: To evaluate the accuracy of analytic planning in patients with bimaxillary surgery.

Material and Methods: This study evaluated 20 patients who underwent bimaxillary surgery. The accuracy of the planning was evaluated by comparing the planned and actual movements of the maxillary and mandibular models. The planning accuracy was measured in millimeters using a digital caliper.

Results: The mean accuracy of the planning was 0.8 mm for the maxillary plane and 0.7 mm for the mandibular plane.

Conclusions: The accuracy of analytic planning in bimaxillary surgery is satisfactory and can be used as a valuable tool for surgical planning.

Traditional Model Surgery Works in My Hands, With My Experience

Clifford E. Muller, DDS* and J. Michael Wallen, DDS*
A matter of Perspective?
Or were we missing the whole picture?

Virtual Surgical Planning: A Brief Overview

• One randomized controlled trial (BJOMS)
• Several in-vivo feasibility studies and retrospective studies

• A modification of resident education:
  — No splint fabrication, no facebow transfer, no model surgery
  — Dependence on technology and medical modeling companies
  — Streamline time and effort, saving resources and labor
  — Simulation of chin surgery cannot be done on plaster models
  — Able to view entire MM complex from all views vs only the teeth on stone models

Virtual Surgical Planning: A Brief Overview

Computer-assisted orthognathic surgery for correction of facial asymmetry: results of a randomised controlled clinical trial
Giacomo De Riu, Silvio Mario Meloni, Alessandro Baj, Andrea Corda, Damiano Soma, Antonio Tallio

In this randomised controlled clinical trial, 2 homogeneous groups of patients with facial asymmetry (n = 10 in each) were treated by either classic or computer-assisted orthognathic corrective surgery. Differences between the 2 groups in the alignment of the lower interincisal point (p = 0.03), mandibular sagittal plane (p = 0.01), and centring of the dental midlines (p = 0.03) were significant, with the digital planning group being more accurate. The primary outcome variables were linear and angular measures that defined the alignment of the facial midlines, or reduction of maxillary and mandibular cant in the 2 groups.

All operations were planned and done by the same surgeon between November 2010 and December 2012. The inclusion criteria were: cant of the occlusal plane of more than 3° or midline discrepancies of more than 2.5 mm, or both; the presence of all central incisors; radiographs and plaster casts taken before and after the operation (classic group), or cranial cone-beam computed tomographic (CT) images (digital group), together with digital photographs taken before and after the operation. Patients were excluded if they had had previous trauma to the hard or soft facial tissues, functional deviation of the mandible, or their records were incomplete (cone-beam CT, radiographs, casts, or digital photographs).
Virtual Surgical Planning: A Brief Overview

Computer-assisted orthognathic surgery for correction of facial asymmetry: results of a randomised controlled clinical trial

Giacomo De Ru, Silvio Mario Meloni, Alessandro Baj, Andrea Corda, Damiano Soma, Antonio Tallio

Classic/Traditional Technique

• Cephalometric Analysis
• Hand articulated models
• Plaster mounted casts transferred with facial bow and CR
• Maxillary and mandibular cast movements made based on vertical and horizontal reference lines at a recorded distance
• Fabrication of splints from models

Virtual Technique

• Cone-beam CT data with specific positioning protocols
• Wax bite registration in CR
• Computer assisted procedure with ‘virtual osteotomies’
• 3D printing of splints: made from scans of models and verified on models sent in from surgeon
• Automated soft tissue remodeling

Virtual Surgical Planning: A Brief Overview

Accuracy of surgical splints: Computer made vs. Man made?


Time and Cost Savings:

Relatively minimal learning curve

Average total virtual preoperative planning: 26 minutes

Average total traditional preoperative planning time: 5 hours
Schools of Thought

- Traditional
- Contemporary

Virtual Surgical Planning: A Brief Overview

Major Advantages:
- Exclusive visualization with VSP only:
- Nasal Anatomy: Turbinectomies, Septoplasties, NLD
- Priniform and Malar Asymmetry: High Midfacial Lefort level osteotomy
- Orbital Dystopia
- Asymmetric Ramus Height: Inverted L Osteotomy
- Chin Anatomy: Yaw Correction, Interpositional Bone grafting, Segmental Contact
- Condylar Torque
- Nerve Anatomy
- Bony Segmental Interferences
Virtual Surgical Planning: A Brief Overview
What else can VSP do for the experienced orthognathic surgeon and surgical orthodontist?

Nuances?
Thank You!

Selected Literature and References

Protocol


Accuracy/Outcomes