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Sequencing Bimaxillary Surgery: Mandible First

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Bimaxillary surgery is often indicated to correct a wide range of maxillomandibular malrelationships. The traditional method of performing bimaxillary surgery has always been to reposition the maxilla first, stabilize it, and then reposition the mandible. However, rigid internal fixation has allowed a change in this classical sequencing[1-3] whereby the mandible is first repositioned and stabilized, followed by repositioning the maxilla.

Either of the surgical sequences can produce similar outcomes when properly planned and executed in the vast majority of bimaxillary cases. The sequence will therefore largely be at the whim of the surgeon. However, we believe there are some cases that are more appropriately and accurately performed in a sequence whereby the mandible is first repositioned and stabilized. The purpose of this article is to discuss such cases.

Prerequisite for Performing Mandibular Surgery First

In most surgeons' hands, bimaxillary surgery requires that one jaw be repositioned and stabilized prior to repositioning the second jaw. In the days of internal wire fixation, the maxilla was the only jaw that could be sufficiently stabilized. Therefore, out of necessity, the maxilla was repositioned and stabilized as an initial step in bimaxillary cases. The factor that has allowed surgical repositioning of the mandible as an initial step is the availability of stable internal fixation devices (ie, plates and/or screws). Therefore, if the mandible is to be first repositioned, it is essential that the osteotomy that is performed is one that lends itself to the application of stable internal fixation. The sagittal ramus osteotomy is perhaps the most commonly used mandibular procedure for the surgical repositioning of the mandible. Fortunately, it readily lends itself to the application of plate and/or screw fixation. Bicortical screws, bone plates, or a combination of them can provide stable internal fixation of the sagittal ramus osteotomy.

However, if one chooses a different osteotomy, such as an intraoral vertical ramus or inverted-L osteotomy, one must be confident in his or her ability to perform stable internal fixation. If this is not guaranteed, then the surgical sequence or the choice of mandibular osteotomy should be altered.

Bimaxillary Cases in Which First Performing Surgery on the Mandible Is Advantageous

DOWNGRAFTING THE POSTERIOR MAXILLA

Whenever one plans to inferiorly reposition the posterior maxilla to decrease the occlusal plane angle, one should consider first repositioning the mandible. The cases for which this is most frequently performed are those in which the occlusal plane angle (and often mandibular plane angle) is steep, for instance, patients with a small vertical posterior facial dimension secondary to condylar degeneration, a lack of condylar growth, ankylosis, and so forth (Fig 1A,B). Such patients have extremely high occlusal and mandibular plane angles. It is virtually impossible to attain an acceptable anterior position of the chin without leveling (decreasing) the occlusal (and mandibular) plane angles. Such a maneuver usually necessitates that the maxillary posterior dentition be repositioned inferiorly.

If one attempts to first reposition the maxilla in such cases, doing so creates an intraoperative anterior open bite (Fig 1C). Depending on the amount of planned inferior maxillary repositioning in the posterior area (counterclockwise rotation), the anterior open bite can be quite large. A few millimeters of inferior repositioning of the maxillary molars can cause several millimeters of anterior open bite. Repo-

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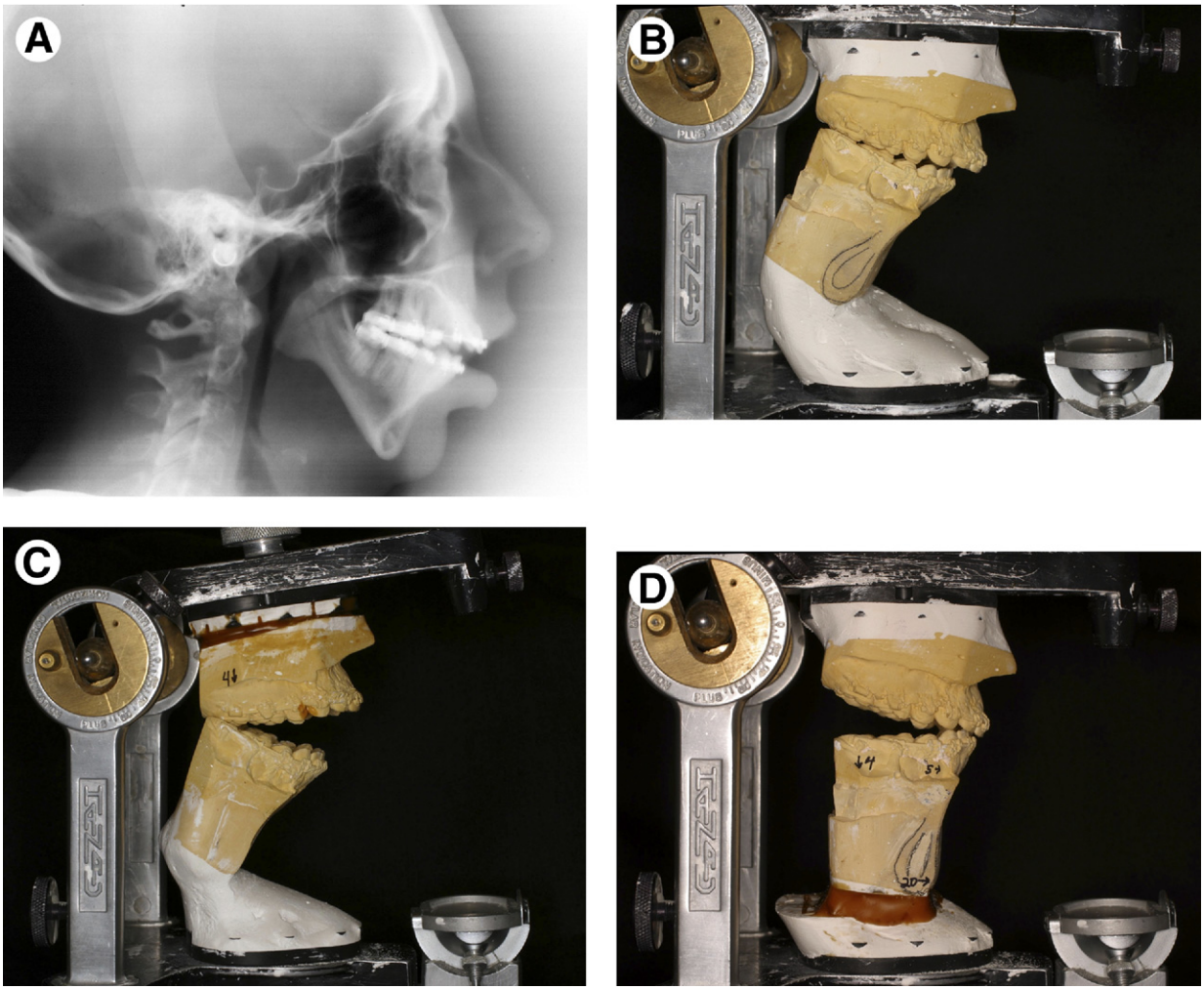

FIGURE 1. Example of 1 case of idiopathic condylar resorption in which the surgical plan involved decreasing the maxillary occlusal plane angle. *A,* Preoperative lateral cephalogram of patient showing extremely steep occlusal and mandibular plane angles. *B,* Patient models mounted on articulator. *C,* Interim position showing relationship of jaws when maxilla is first repositioned. In this case, the posterior maxilla is repositioned inferiorly 4 mm. Note, large anterior open bite that results and elevation of upper member of articulator indicating amount to which the mandible would have to rotate "open" during surgery to accommodate the surgical splint. *D,* Interim position showing relationship of jaws when the mandible is first repositioned. Note, development of posterior open bite. Also, note, upper member of articulator is horizontal, indicating that mandibular ramus does not have to rotate "open" to accommodate mandibular repositioning.

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sitioning the maxilla first in such cases causes 2 potential problems. First, the splint that must be fabricated and used will be extremely thick in the anterior region, and it can be difficult to insert and perform maxillomandibular fixation (MMF). More importantly, however, is that for the posterior maxillary molars to be inferiorly repositioned, the mandible will have to rotate "open," or clockwise to permit this maxillary movement. The rotation of the condyle induced by the "opening" movement of the mandible can cause anterior and, possibly, inferior translation of the condyle down the slope of the articular eminence. Because of the altered condylar position, the mandible is no longer in its proper preoperative (centric relation) position. Because the mandible is being used to help position the maxilla through the use of the interim splint, the maxilla will, therefore, not end in the planned (desired) postoperative position.

If one were to first reposition the mandible, a posterior open bite will be created intraoperatively (Fig 1D). This is a much easier surgery to perform, and it can maintain the preoperative position of the mandibular condyle. Furthermore, the relationship of the anterior teeth will be much more favorable and the application of MMF will be greatly facilitated. Once the mandibular osteotomy has been stabilized, the posterior open bite is readily closed by performing a maxillary osteotomy and dropping the posterior maxilla into occlusion with the mandibular dentition.

WHEN UNSURE IF THE INTEROCCLUSAL (BITE) REGISTRATION IS CORRECT

Bimaxillary surgery usually requires that the casts be properly mounted on an articulator. This requires an accurate facebow transfer to mount the maxillary cast and an accurate interocclusal registration to mount the mandibular cast. An accurate interocclusal registration is usually taken with the mandible in a centric relation because that is considered the most reproducible position and is the position the condyles will assume when the patient is under general anesthesia during surgery. When the maxilla is to be repositioned first, the interim splint will be fabricated between the repositioned maxillary cast and the unoperated mandibular cast. If the interocclusal registration is inaccurate, the interim splint will not be able to provide the proper position for the maxilla intraoperatively, because the mandibular position at surgery will be different than what it was on the articulator.

For instance, if a patient has a functional shift of 3 mm to the right and this was not recognized during the interocclusal registration, when the mandibular cast is mounted on the articulator, the mandibular midline will be 3 mm to the right of where it actually is in the patient when they are in a centric relation. During surgery, the functional shift will disappear because of muscle relaxation. The mandible will then assume its centric relation position, which will bring the mandibular midline 3 mm to the left of what was recorded with the interocclusal registration. Because the interim splint was made between the malpositioned mandibular cast and the repositioned maxillary cast, during surgery, when the mandible assumes its centric position, the maxillary midline will be positioned 3 mm to the left of what was actually planned. This, of course, would be a devastating problem if unrecognized during surgery.

However, if one chooses to first operate on the mandible, an inaccurate interocclusal registration is of no consequence. The reason for this is that even if the mandible is erroneously mounted 3 mm to the right, the interim splint will relate the unoperated maxilla to the desired position of the mandible, which should have been accurately obtained during the model surgery. During the actual surgery, once the osteotomy has been performed, the interim splint inserted, and MMF applied, the mandible will be properly positioned. The 3 mm of malposition on the articulator will be of no consequence. The condyles are simply repositioned into the fossae, and fixation is applied to stabilize the segments.

The above discussion brings out one of the most important details of orthognathic surgery. When one chooses to use the unoperated mandible to reposition a maxilla (this occurs in isolated maxillary surgery and in bimaxillary surgery in which the maxilla is first repositioned), one should always check the bite of the patient after they are intubated and under a state of general anesthesia to ensure that the bite is the same as it was on the articulated models. If it is not, one cannot use the mandible to position the maxilla. Doing so will cause a malposition of the maxilla. In a bimaxillary surgery case, when this happens, one has 2 options: *1*) take an intraoperative interocclusal registration and delay the surgery until an appropriate model surgery and interim splint can be fabricated (Fig 2); or, *2*) if one has not performed surgery on the original mounted models, an interim splint can be made that relates the unoperated maxillary to the repositioned mandibular model and mandibular surgery performed first. One can readily make a splint with a firm impression material or acrylic in the operating room (Fig 3).

WHEN INTRAOPERATIVE MMF IN THE INTERIM POSITION WILL BE DIFFICULT

Bimaxillary surgery usually requires that an interim splint will be used intraoperatively and that MMF be used during the repositioning of the first jaw. Some occlusal relationships and surgical movements of the first jaw make the intraoperative placement of MMF quite difficult, for instance, when performing bimaxillary advancements, especially in patients with an existing Class II relationship. In such cases, if the maxilla is first advanced, a very large overjet relationship of the dentition will result (Fig 4A). Placing MMF wires can only be performed in the area in which the upper and lower teeth are opposite one another. This limits the application of MMF wires to the molar and perhaps premolar region. It then becomes difficult to maintain the anterior teeth in the splint.

In such cases, performing mandibular advancement will first facilitate the application of the MMF wires because the anterior teeth can be used for this purpose, and the posterior dentition will simply come together, with little need for additional wires (Fig 4B).

WHEN FIXATION OF THE MAXILLA MAY NOT BE RIGID

When first repositioning the maxilla during bimaxillary surgery, the maxilla is plated in its new position before mandibular osteotomy. After the mandible undergoes osteotomy, it is placed into final occlusion with the maxilla by way of MMF wires. With large mandibular movements, considerable force can be required to hold the mandible in its final position while undergoing osteosynthesis of the mandibular fragments. If the maxillary bone is extremely thin and fragile, the screws holding the maxillary bone plates can pull out, creating an intraoperative dilemma, because all reference to stable structures are then lost.

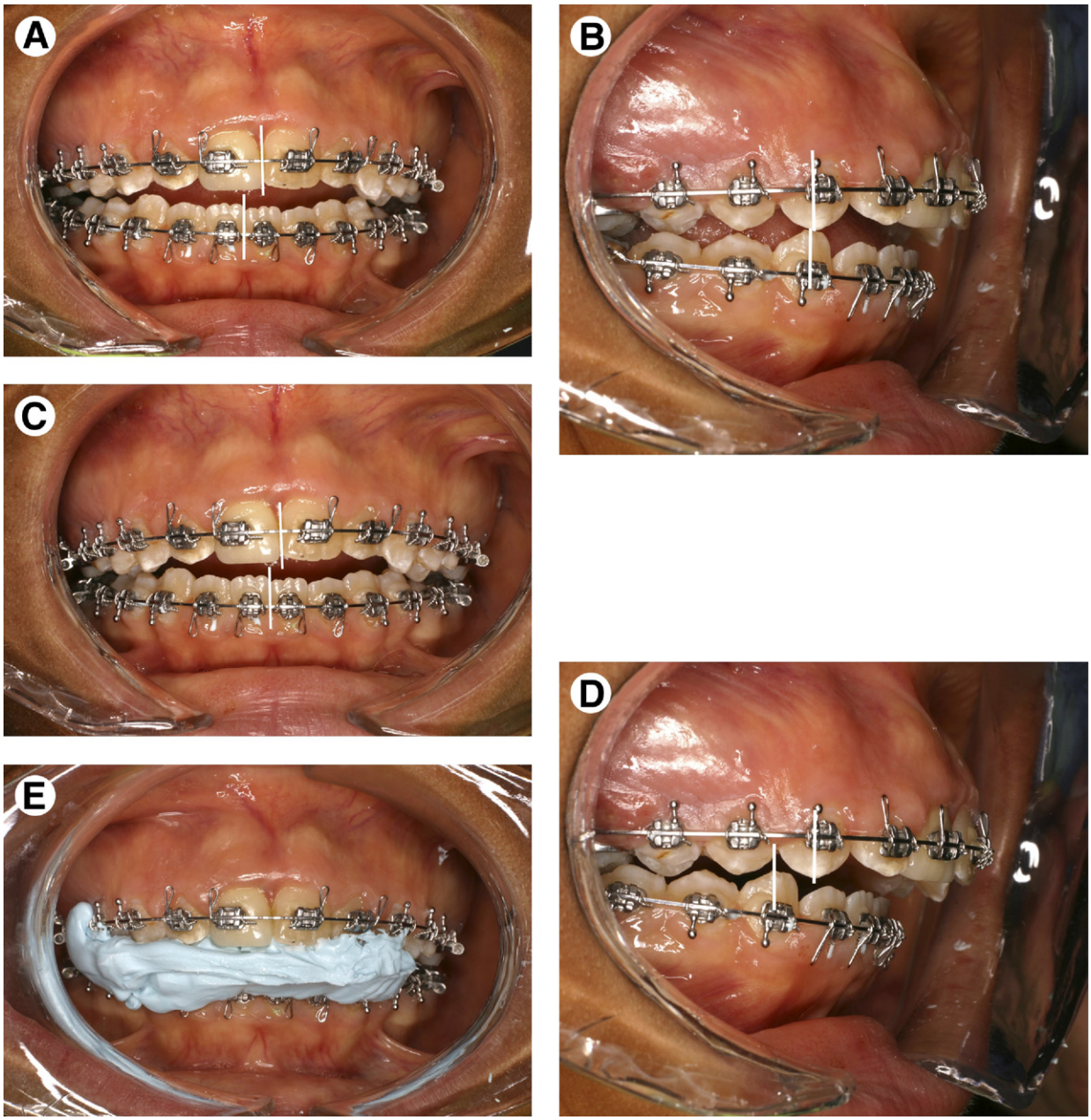

FIGURE 2. Case in which interocclusal registration was not accurately performed. *A*, Frontal and *B*, lateral views of occlusion taken before surgery. After patient was anesthetized, occlusion appeared differently. *C*, Midline discrepancy was less and *D*, overjet was greater. *E*, It was decided to take an intraoperative interocclusal registration and delay the surgery until new model surgery could be performed.

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If it can be anticipated that considerable force will be required to maintain MMF during the mandibular osteosynthesis, performing surgery in the mandible first might be prudent.

WHEN PERFORMING CONCOMITANT TEMPOROMANDIBULAR JOINT SURGERY

Most surgeons believe that the temporomandibular joints (TMJs) are the foundation for orthognathic surgery. If the TMJs are not stable and healthy (ie, pathologic), orthognathic surgery outcomes might be unsatisfactory relative to the function, esthetics, stability, and pain.[4-8] It has also been demonstrated that many patients presenting for orthognathic surgery have associated disk abnormalities (ie, malposition, malfunction, perforation) that if not repaired can compromise the final result and long-term predictability of the orthognathic surgery.[9-11] Because of this, some surgeons perform concomitant TMJ and orthognathic surgery.

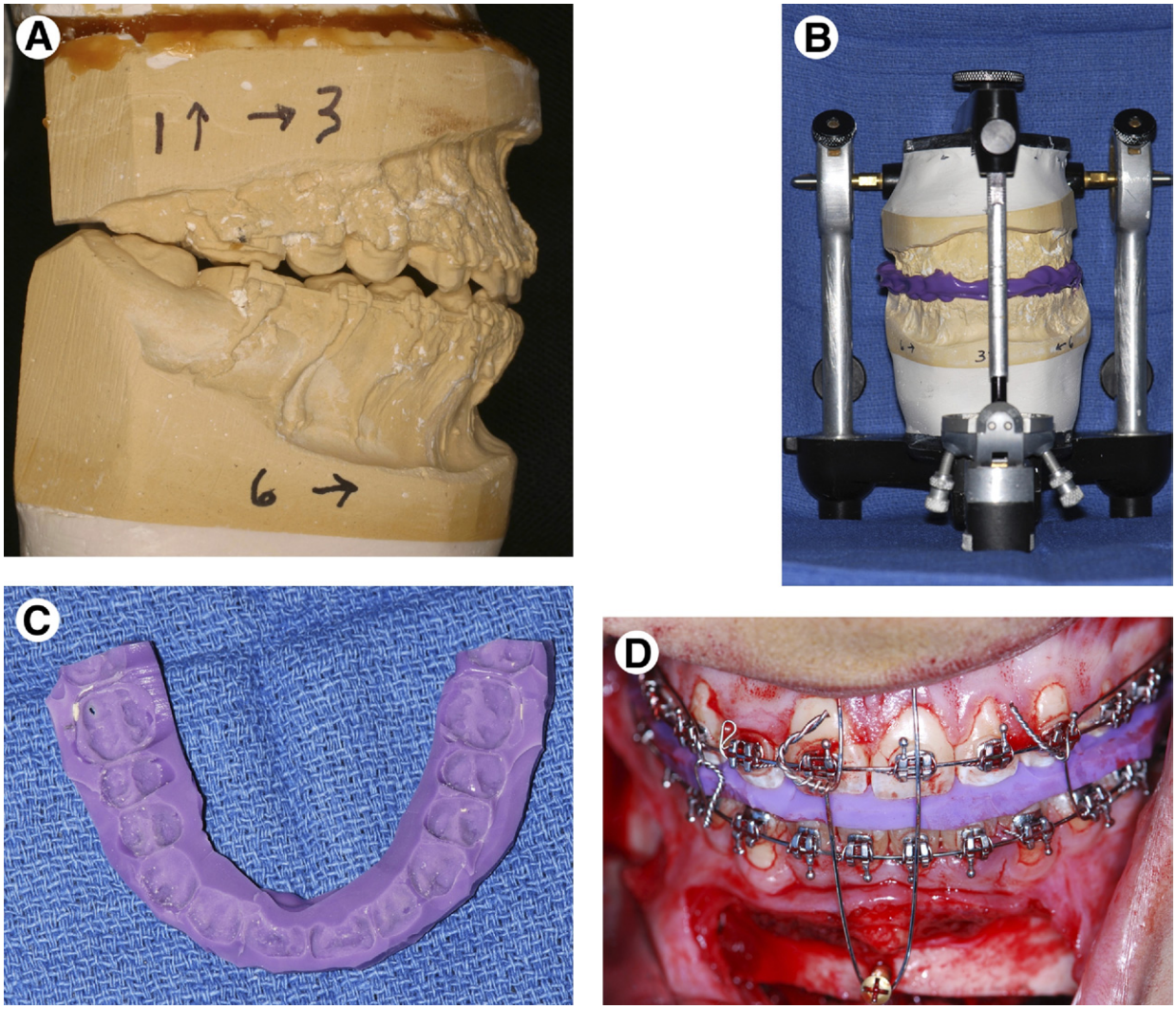

FIGURE 3. Another case in which the occlusion with the patient under anesthesia was different from the preoperative records. *A,* Models after simulated bimaxillary surgery. Because the original mounted models had not been used for model surgery, it was possible to articulate the original (unoperated) maxillary model with the final (operated) mandibular model and *B,* make a splint. *C,* For expediency, the splint was fabricated with impression material, but acrylic could also have been used. *D,* The splint was then used to perform surgery first on the mandible, followed by maxillary surgery.

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When performing concomitant TMJ and bimaxillary orthognathic surgery, one has 2 choices of sequencing. However, no matter which sequence one chooses, the TMJ surgery must be performed before mandibular osteotomy. The reason for this is that the position of the condyle within the TMJ will be altered by the TMJ surgery. If the mandibular surgery were performed before the TMJ surgery, a malocclusion could result from an alteration in the position of the condyle. Similarly, if one first performed TMJ surgery, maxillary repositioning, and then mandibular osteotomy, the maxilla could be malpositioned. The reason for this is that the position of the condyles in the TMJ would be altered after the TMJ surgery, and, then when the mandible is used to help position the maxilla using an interim splint, the maxilla would be malpositioned.

The first sequence one could choose when performing concomitant TMJ and bimaxillary surgery would be to first reposition the maxilla, then to perform the TMJ surgery, and then the mandibular osteotomy. The second sequence one could choose would be to first perform the TMJ surgery, then the mandibular osteotomy, and then to reposition the maxilla. Both should give the same outcome. However, the first sequence would make it much more difficult to maintain sterility during the TMJ surgery. One would have to try and maintain separate surgical fields (TMJ and oral cavity) and have a

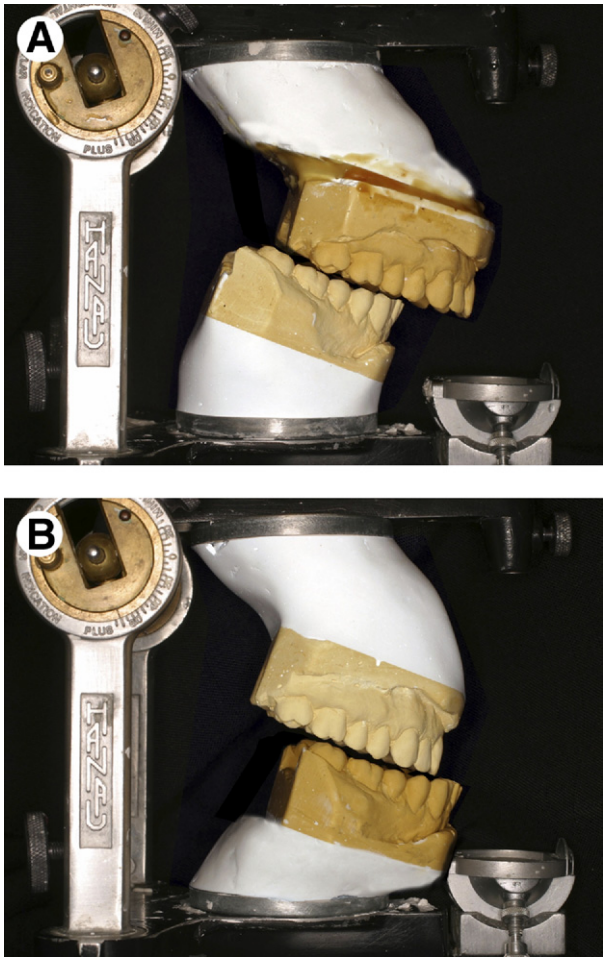

FIGURE 4. Models of Class II patients who had undergone treatment planning for bimaxillary advancement. *A*, Note, if the maxilla is advanced first, a huge overjet will be created, making application of MMF difficult. *B*, However, if the mandible is advanced first, MMF will be much more easily facilitated.

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second set of sterile instruments available for the TMJ surgery. When performing TMJ surgery first, the same set of instruments used for the TMJ can be used for the mandibular and, subsequently, maxillary surgery.

AS A ROUTINE SEQUENCE?

In addition to what we have discussed, there is another reason to consider always performing mandibular surgery before maxillary. The TMJ is not a discreet "ball and socket" joint. The mandibular condyle rotates and translates within the TMJ. Because of this, a risk exists of slight inaccuracies in the condylar position after mandibular osteotomy. After mandibular osteosynthesis and the release of MMF to check the bite, slight inaccuracies might be detected, requiring the surgeon to reset the mandibular osteosynthesis until the occlusion is appropriate.

Very small discrepancies (1 mm or less) might be difficult to correct no matter how many times the surgeon repositions the condyle and resets the osteosynthesis. Even small discrepancies can create significant occlusal interferences. The maxilla, however, is connected to the skull base, and it remains in place after osteotomy and osteosynthesis, unless the fixation is put to extreme forces. Therefore, maxillary repositioning is associated with better accuracy than mandibular surgery.

This was corroborated by Béziat et al[12] in 2009. They reported that changes in the anteroposterior direction were found after bilateral sagittal split osteotomy 74% of the time, with an average magnitude of 0.32 mm. Changes in the transverse dimension after bilateral sagittal split osteotomy were less frequent (54% of cases), and the magnitude was less (0.19 mm). With maxillary repositioning, they found that the average error in the anteroposterior direction was extremely small (0.02 mm) and that it only occurred in 8% of the cases. No errors were found in the transverse dimension for maxillary surgery.

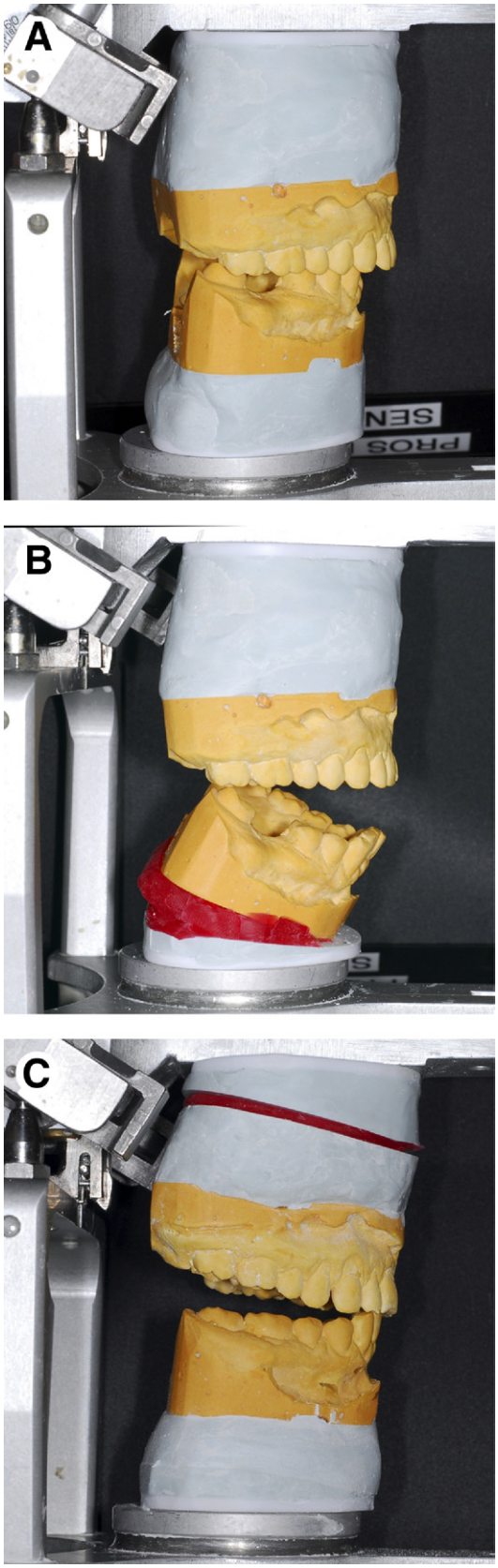
The errors that might be inadvertently created by performing mandibular surgery last would potentially be eliminated and not translated to the occlusion if the maxilla was instead positioned last. For instance, a 1-mm malposition of the mandible performed after maxillary surgery would create a malocclusion; however, the same malposition of the mandible performed first would not. The maxilla would instead be malpositioned this slight amount to accommodate the appropriate occlusion. Slight malpositions (ie, 1 mm or less), even in the incisor area, are not usually clinical problems. However, a 1-mm malocclusion could be a problem.

Planning Techniques for Mandible-First Bimaxillary Surgery

Several techniques are available to perform model surgery and create an interim splint to perform mandibular surgery first during bimaxillary cases. Each can provide the same outcome, with the choice up to the surgeon.

Two methods are available to perform accurate model surgery in cases in which the mandible will first be repositioned that are similar to when the maxilla is to be repositioned first, with the exception of the splint fabrication. When only one set of models is available, the steps include the following:

1. Facebow transfer to mount maxillary cast
2. Interocclusal registration to mount mandibular cast
3. Reposition mandibular cast into final position on articulator



4. Fabricate interim splint between the repositioned mandibular cast and the unoperated maxillary cast
5. Maxillary cast positioned into final occlusion with repositioned mandibular cast (after segmentation prn)
6. Fabricate final splint, if needed, between the repositioned maxillary and mandibular casts in their final occlusal relationship

When 2 sets of articulated casts are available, the steps include the following:

1. Facebow transfer to mount maxillary cast
2. Interocclusal registration to mount mandibular cast
3. Reposition one maxillary cast into final position on articulator (after segmentation prn)
4. Reposition one mandibular cast into occlusion with repositioned maxillary cast (the previous 2 steps can be reversed)
5. Fabricate interim splint between the unoperated maxillary cast and the repositioned mandibular cast
6. Fabricate final splint, if needed, between the repositioned maxillary and mandibular casts in their final occlusal relationship

Note that the second technique requires 2 sets of articulated casts—1 that is cut and 1 that is not cut. Having an uncut set of articulated casts allows one to always have them available to check the bite once the patient is under general anesthesia in the operating room. Also, splint fabrication can occur in any order by simply removing and replacing an uncut model for an operated one.

Alternate techniques of performing model surgery for bimaxillary surgery when the mandible is to be repositioned first have also been reported.[3] This technique was later modified by Wolford and Galiano,[13] who no longer use a facebow to mount the maxillary cast. The new mounting technique uses an occlusal table positioning device that attaches to the articulator and allows the surgeon to position the maxilla

FIGURE 5. *A,* Case in which a patient with a very low occlusal plane angle was scheduled to undergo maxillary posterior impaction combined with anterior maxillary downgrafting and mandibular osteotomy to steepen the occlusal plane angle. *B,* If mandibular surgery were performed first, a large anterior open bite would be created intraoperatively, making insertion of a splint and MMF difficult during surgery. *C,* However, if the maxilla were treated first, a posterior open bite would be created. This would be much easier to stabilize. The mandibular surgery would then be performed, closing the posterior open bite.

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according to the occlusal plane angle traced from the cephalometric radiograph and the clinical measures for maxillary cant and midline rotations. However, this technique requires that the mandibular surgery is always performed first.[13]

Potential Disadvantages of Performing Surgery on Mandible First

As with all techniques, potential disadvantages exist that should also be mentioned. Most important is that performing mandibular surgery first requires that the mandible has been stabilized by internal fixation devices. This might not always be possible. For instance, an unfavorable split of a sagittal ramus osteotomy could make stable internal fixation impossible. In such cases, the mandible cannot be used to position the maxilla; thus, the maxillary osteotomy might need to be delayed. A period of MMF with the interim splint in place might be required to obtain healing of the segments. This potential problem would rarely be encountered if performing maxillary surgery first.

When one is to perform a clockwise rotation of the maxillomandibular complex to close an anterior open bite using posterior maxillary intrusion or to anteriorly downgraft the maxilla to increase tooth show, performing the mandible surgery first might be more difficult owing to the transient anterior open bite created by clockwise rotation of the occlusal plane (Fig 5). In this situation, performing the maxillary surgery first and allowing the mandible to temporarily rotate clockwise will make the model surgery easier (Fig 5C).

In summary, whether surgeons choose to alter their surgical sequencing of bimaxillary osteotomies on a case by case basis or routinely will be up to them. However, we firmly believe that some cases (such as we have presented) will be better treated by first repositioning the mandible. Whether a surgeon chooses to routinely perform mandibular surgery first during bimaxillary surgery will depend on a host of factors, including her or his ability to predictably perform mandibular osteotomy that can be stabilized, her or his ability to take and trust her or his interocclusal registrations, and her or his bias. However, we hope that we have given those who have never used this sequence something to consider.

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