

# Surgery First in Orthognathic Surgery: What Have We Learned? A Comprehensive Workflow Based on 45 Consecutive Cases

Federico Hernández-Alfaro, MD, DDS, PhD, FEBOMS,\*  
Raquel Guijarro-Martínez, MD, DDS,† and María A. Peiró-Guijarro, DMD‡

**Purpose:** In some patients, “surgery first” (SF) may represent a reasonable approach for the expedited correction of a maxillofacial deformity. Based on the prospective evaluation of a large sample, this article provides a specific orthodontic and surgical protocol, discusses the benefits and limitations of this approach, and updates its indications.

**Materials and Methods:** Forty-five patients were managed with an SF approach. Selected cases presented symmetrical skeletal malocclusions with no need for extractions or surgically assisted rapid palatal expansion. Periodontal or temporomandibular joint problems and management by an orthodontist without experience in orthognathic surgery were considered exclusion criteria. Virtual treatment planning included a 3-dimensional orthodontic setup. Standard orthognathic osteotomies were followed by buccal interdental corticotomies to amplify the regional acceleratory phenomenon. Miniscrews were placed for postoperative skeletal stabilization. Orthodontic treatment began 2 weeks after surgery. Archwires were changed every 2 to 3 weeks. At 12-month follow-up, patient satisfaction and orthodontist satisfaction were evaluated on a visual analog scale of 1 to 10. Descriptive statistics were computed for all study variables.

**Results:** The studied sample consisted of 27 women and 18 men (mean age, 23.5 yr). The main motivation for treatment was the wish to improve facial esthetics. Bimaxillary surgery was the most common procedure. Mean duration of orthodontic treatment was 37.8 weeks, with an average of 22 orthodontic appointments. Mean patient and orthodontist satisfaction scores were 9.4 (range, 8 to 10) and 9.7 (range, 8 to 10), respectively.

**Conclusions:** The SF approach significantly shortens total treatment time and is very favorably valued by patients and orthodontists. Nevertheless, careful patient selection, precise treatment planning, and fluent bidirectional feedback between the surgeon and the orthodontist are mandatory.

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The conventional approach to orthognathic surgery requires a variable length of preoperative orthodontic preparation, the surgery, and a relatively stable period of postoperative orthodontics. The importance of preoperative orthodontics rests on the fact that optimal

skeletal positioning during surgery may be limited by inappropriate dental alignment. However, orthodontic preparation lasts 15 to 24 months,<sup>1-3</sup> involves progressive deterioration of facial esthetics and dental function, and causes significant patient discomfort.<sup>1,4-6</sup>

\*Director, Institute of Maxillofacial Surgery, Teknon Medical Center Barcelona, Barcelona, Spain; Chair, Department of Oral and Maxillofacial Surgery, Universitat Internacional de Catalunya, Barcelona, Spain.

†Institute of Maxillofacial Surgery, Teknon Medical Center Barcelona, Barcelona, Spain; Associate Professor, Department of Oral and Maxillofacial Surgery, Universitat Internacional de Catalunya, Barcelona, Spain.

‡Fellow, Department of Orthodontics (International Diploma in Orthognathic Surgery and Surgical Orthodontics), Universitat Internacional de Catalunya, Barcelona, Spain. Private practice in Orthodontics, Valencia, Spain.

Address correspondence and reprint requests to Dr Guijarro-Martínez: Institute of Maxillofacial Surgery, Teknon Medical Center Barcelona, Vilana, 12, D-185, 08022 Barcelona, Spain; e-mail: [guijarro.raq@gmail.com](mailto:guijarro.raq@gmail.com)

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**Table 1. AUTHORS' STANDARDIZED PROTOCOL FOR SURGERY-FIRST ORTHOGNATHIC PROCEDURES**

Diagnostic work-up	Clinical evaluation by combined orthodontic-surgical team CBCT Intraoral scan
Preoperative planning	Generation of augmented virtual skull model by file fusion 3D virtual orthodontic setup and planning of future dental movements 3D virtual planning of skeletal movements CAD-CAM generation of intermediate splint Conventional fabrication of end splint
Preoperative orthodontic preparation	Bracket bonding 1 wk before surgery Placement of soft arch the day before surgery
Surgery	Placement of 4-8 2.0-mm miniscrews Minimally invasive orthognathic surgery Systematic performance of buccal interdental corticotomies with piezoelectric microsaw Elective bone augmentation with hydroxyapatite blocks in gaps >3 mm For maxillary segmental surgery, fixation of end splint to maxilla
Postoperative orthodontics	Initiation of orthodontic movements 2 wk after surgery Archwire change every 2-3 wk

Abbreviations: 3D, 3-dimensional; CAD, computer-assisted design; CAM, computer-assisted manufacturing; CBCT, cone-beam computed tomography.

Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. *Surgery First in Orthognathic Surgery*. *J Oral Maxillofac Surg* 2013.

An alternative methodology is the “surgery-first” (SF) approach. Proposed by Nagasaka et al<sup>7</sup> in 2009, this method proceeds with orthognathic surgery without presurgical orthodontic preparation and is followed by regular postoperative dental alignments. Although minor orthodontic movements are occasionally performed before surgery, the concept implies that most of the orthodontic treatment is performed postoperatively.<sup>8</sup> Compared with the traditional approach, SF protocols lead to a significant decrease in total treatment time. This fact has a very positive influence on patients' global satisfaction with treatment. The high orthodontic efficiency observed in SF cases might respond to the combination of 2 factors. First, the starting point is the correction of the skeletal bases. In consequence, the complexity of orthodontic treatment is decreased, and soft tissue imbalances that might interfere with certain orthodontic movements are eliminated from the start.<sup>9</sup> Second, tooth movement is accelerated owing to the increased postoperative metabolic turnover.<sup>5,9,10</sup>

Based on the excellent clinical outcomes of mono-maxillary cases treated with a SF approach,<sup>7,9</sup> in 2011 the authors published the first report of bimaxillary cases treated with this methodology.<sup>5</sup> The optimal esthetic and functional results, significant reduction in total treatment time, and high patient satisfaction led to the postulation that SF may represent a reasonable, cost-effective method to manage skeletal malocclusion in selected cases, and that it has the potential to become a standard approach to orthognathic surgery in the

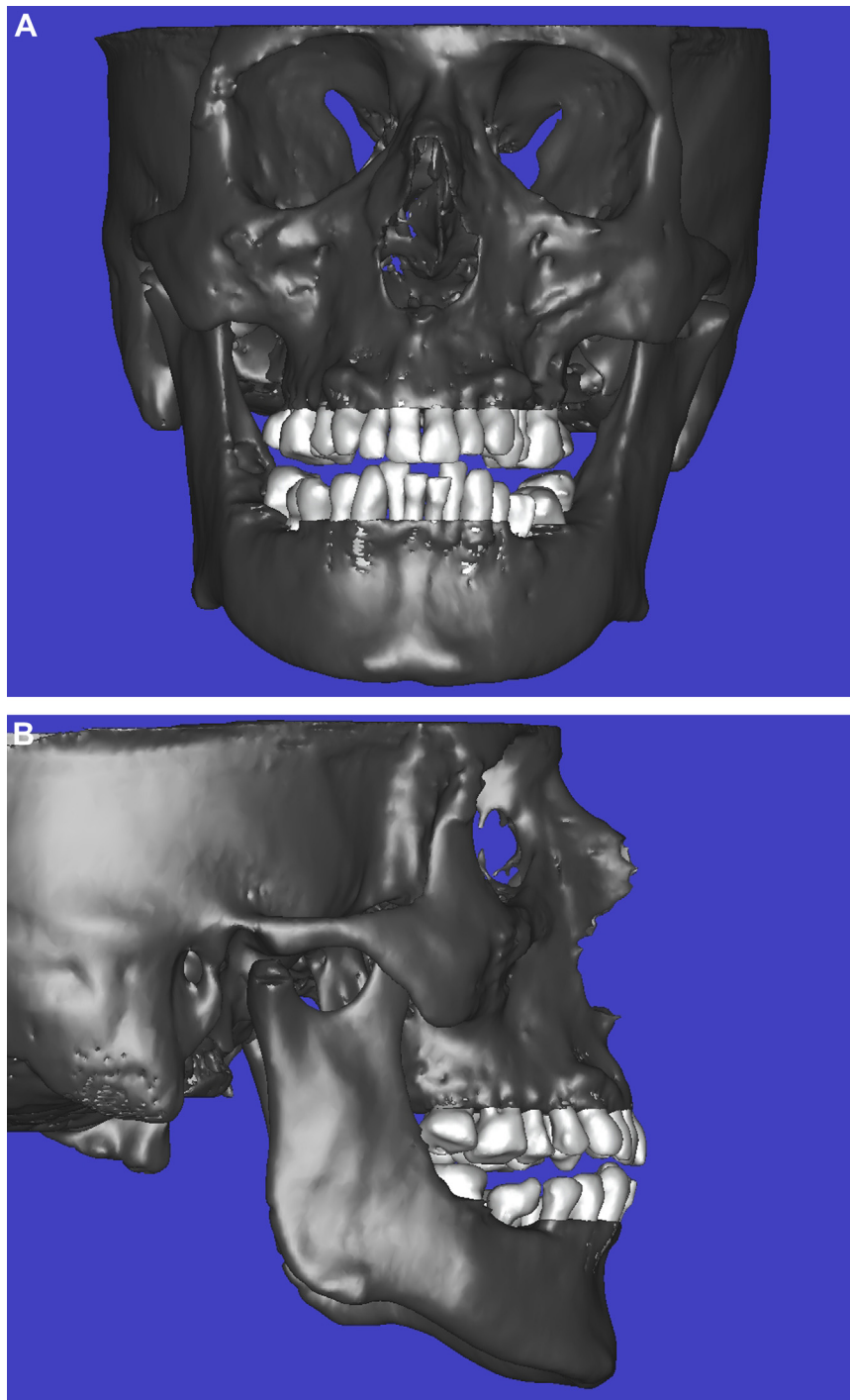
future.<sup>5,7</sup> After substantial investigation and technical refinement based on the prospective evaluation of a large sample, the aim of this study was to describe a specific orthodontic and surgical protocol for SF, discuss the benefits and limitations of this treatment concept, and update its indications.

## Materials and Methods

### STUDY DESIGN

Of a total of 230 orthognathic surgical procedures performed during a 2-year period (June 2010 to June 2012), 45 patients (19.6%) were managed with an SF approach. The Declaration of Helsinki guidelines on medical protocol and ethics were followed. Under institutional review board approval, a prospective evaluation of these SF cases was designed.

Patients were selected for an SF sequence based on the following inclusion criteria: 1) skeletal malocclusion requiring combined orthodontic and surgical treatment without extractions; 2) informed consent for this novel protocol; and 3) orthodontic management by an officially qualified orthodontist with experience in orthognathic surgery. Exclusion criteria consisted of the following conditions: 1) severe crowding requiring extractions; 2) inexperienced orthodontist; 3) transverse maxillary hypoplasia requiring previous surgically assisted rapid palatal expansion (SARPE); 4) severe asymmetry with 3-dimensional (3D) dental compensations; 5) Class II Division 2 malocclusion with overbite; 6) acute periodontal problems; and 7) underlying



**FIGURE 1.** Three-dimensional virtual planning: simulation of skeletal movements and virtual orthodontic setup. A,B,C, Baseline. (Fig 1 continued on next page.)

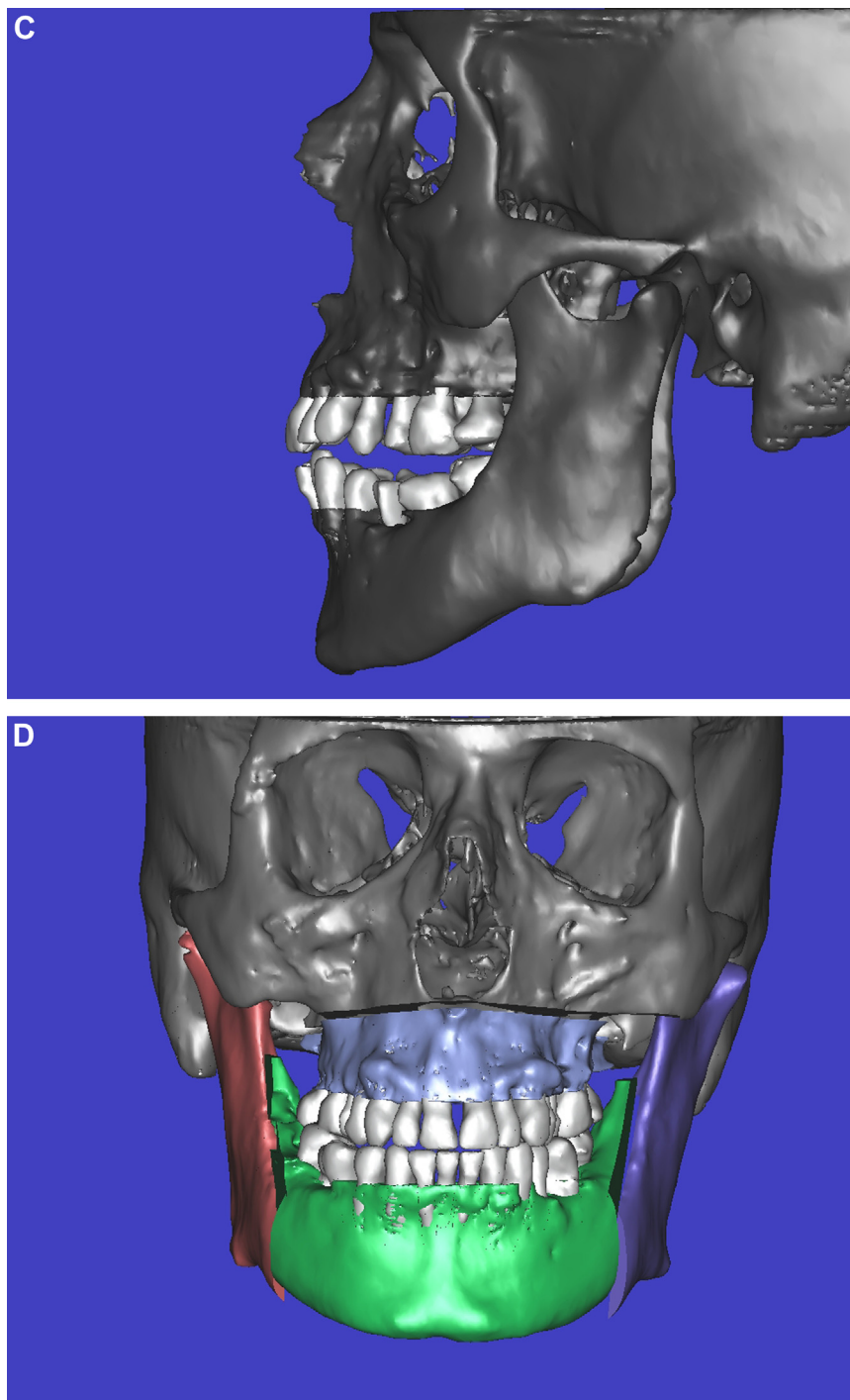
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temporomandibular joint (TMJ) disease or uncontrolled TMJ-related symptomatology.

#### PREOPERATIVE WORKFLOW

Diagnostic workup, preoperative planning, orthodontic preparation, and surgical execution proceeded

according to the authors' center's standardized protocol for SF orthognathic procedures (Table 1). Diagnostic workup included routine clinical assessment by the combined orthodontic and surgical team and radiologic evaluation with cone-beam computed tomography (CBCT; IS i-CAT 17-19, Imaging Sciences International, Hatfield, PA). The following radiologic

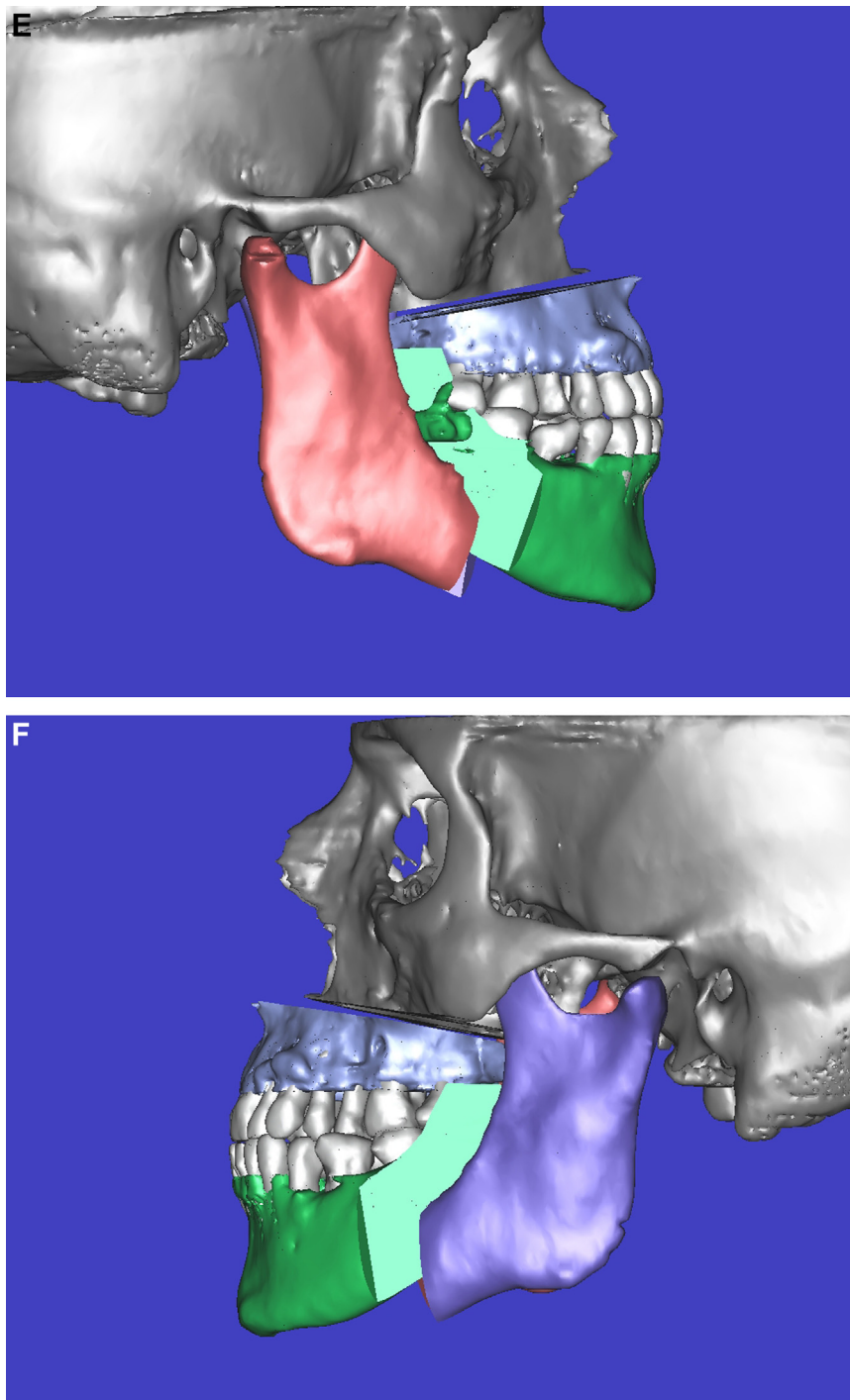


**FIGURE 1 (cont'd).** *D, E, F*, Treatment plan simulation. In this case, a bimaxillary osteotomy with maxillomandibular advancement and anticlockwise rotation of the occlusal plane with a mandible-first approach was planned. Note the foreseen orthodontic alignment of the anterior crowding and leveling of the Spee curve. (**Fig 1 continued on next page.**)

*Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. Surgery First in Orthognathic Surgery. J Oral Maxillofac Surg 2013.*

parameters were used: 120 kV, 5 mA, and 7-second scan time. The axial slice distance for each scan was 0.300 mm<sup>3</sup>. A 23-cm field of view was used. Primary images were stored as 576 Digital Imaging and Communications in Medicine (DICOM) data files. The resulting raw file from each skull was segmented with SimPlant

Pro OMS software (Materialise Dental, Leuven, Belgium) to obtain a “clean” 3D representation, which was stored as a stereolithography (STL) file. Subsequently, dental arch anatomy was registered with an intraoral digital scanner (Lava Scan ST scanner; 3M ESPE, Ann Arbor, MI). The 2 STL files (CBCT scan plus dental scan) were

**FIGURE 1 (cont'd).**

*Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. Surgery First in Orthognathic Surgery. J Oral Maxillofac Surg 2013.*

fused by SimPlant Pro OMS using a “best-fit” algorithm.<sup>11</sup> Hence, an augmented skull model was obtained.

The necessary dental movements were anticipated by performing a 3D virtual orthodontic setup on the skull model. The planned osteotomies were simulated too. (Fig 1). For each case, an individualized treatment plan with a maxilla- or mandible-first protocol was

designed. The resulting file with the temporary intermaxillary relation served to produce the intermediate splint by computer-assisted design (CAD) and computer-assisted manufacturing (CAM) technology. The end splint was fabricated conventionally.

With the exception of bracket bonding 1 week before surgery, no other preoperative orthodontic

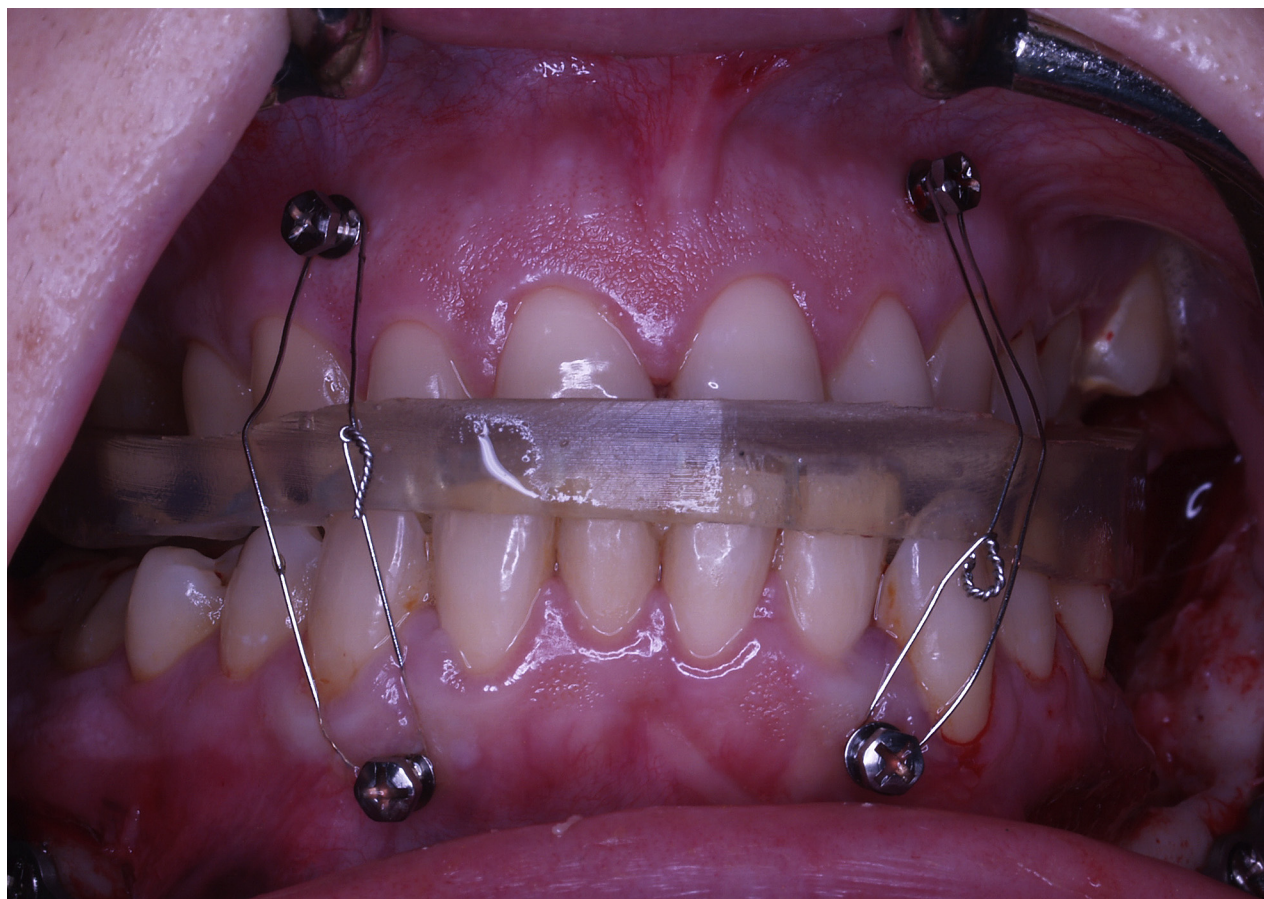
preparation was implemented. To avoid dental movements that could render the CAD-CAM splint inaccurate and thus interfere with proper bone positioning during the operation, the first soft archwire was not placed until 24 hours before surgery. In some cases, the first archwire was installed at the first postoperative orthodontic appointment 1 to 2 weeks after surgery.

#### SURGICAL PROCEDURE

Forty-three patients were operated on under general anesthesia and controlled hypotension. Two more underwent mandibular surgery under local anesthesia plus sedation.<sup>12</sup> Before incision, 4 to 8 transmucosal 2.0-mm miniscrews (KLS Martin GmbH & Co, Umkirch, Germany) were placed. In cases in which the maxilla was not to be segmented, 4 screws between the canines and the first premolars or between the lateral incisors and the canines were installed (Fig 2). Whenever maxillary segmentation was planned, 4 additional screws were placed between the second premolars and the first molars to aid in transverse and vertical control. If extreme counterclockwise rotation of the bimaxillary complex was anticipated, the same

8 screws were used to counteract muscle traction together with Class II elastics (Fig 4D).

The surgery proceeded according to the authors' minimally invasive protocol, which has been described in detail elsewhere.<sup>13</sup> In addition, corticotomies were executed in the maxilla and mandible to accelerate postoperative orthodontic movement according to the regional acceleratory phenomenon (RAP) theory.<sup>14</sup> These corticotomies were performed with a piezoelectric microsaw (Implant Center 2, Satelec-Acteon Group, Tuttlingen, Germany). Whenever the targeted teeth were not accessible through the incision required for the orthognathic procedure, a tunnel approach under endoscopic assistance was used.<sup>15</sup> Corticotomies were extended through the entire thickness of the buccal cortical layer and interrupted when penetrating the medullary bone. No luxation maneuvers were performed after any of the corticotomies (Fig 3). Before wound closure, elective bone augmentation with hydroxyapatite blocks (Bio-Oss Block; Geistlich Pharma AG, Wolhusen, Switzerland) was performed in all osteotomy gaps wider than 3 mm. Similarly, selected areas with radiologically thin cortical plates or bone dehiscences detected directly or indirectly (under endoscopic



**FIGURE 2.** In cases in which the maxilla is not segmented, 4 transmucosal 2.0-mm miniscrews are placed.



**FIGURE 3.** Bimaxillary surgery with maxillary segmentation *A*, before and *B*, after the execution of buccal interdental corticotomies with a piezoelectric device to accelerate postoperative orthodontic movement. In addition to the longitudinal cortical cuts, selective cortical drilling was performed to further promote the regional acceleratory phenomenon. (**Fig 3 continued on next page.**)

*Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. Surgery First in Orthognathic Surgery. J Oral Maxillofac Surg 2013.*

assistance) were grafted. Whenever the maxilla was segmented, the end splint was ligated with 0.12-mm interdental wire loops and left in place for 2 weeks.

#### POSTOPERATIVE WORKFLOW

After a healing period of 2 weeks postoperatively, orthodontic treatment began. Archwires were changed every second to third week. In segmented maxillas, “Z” elastics provided additional transversal control. During the first postoperative month, miniscrews were used for skeletal anchorage, thereby avoiding premature loading of the orthodontic appliances and undesirable dental extrusions.

At 1-year follow-up, patient satisfaction with treatment outcome was assessed with a visual analog scale (VAS) ranging from 0 (not satisfied at all) to 10 (greatest possible satisfaction). On a similar VAS, orthodontists

were asked to rate their overall subjective impression of the selected treatment approach.

## Results

#### DEMOGRAPHIC VARIABLES

During the prospectively evaluated 2-year period, 27 women and 18 men were managed according to the SF protocol. Mean age at the time of surgery was 23.5 years (range, 17 to 36 yr).

#### CHIEF COMPLAINT AND REFERRAL CONTEXT

Patients’ most common chief complaint and main motivation for treatment was the wish to improve facial esthetics (Table 2).

More than 50% of patients were self-referred (Table 2). Of the latter, 15 expressed their concern



**FIGURE 3 (cont'd).** B, Cortical bone from the maxillary osteotomy was used to graft the right gap of the frontal maxillary segment.

*Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. Surgery First in Orthognathic Surgery. J Oral Maxillofac Surg 2013.*

about long-lasting orthodontic treatment and requested an SF approach.

#### SKELETAL DIAGNOSIS

Of 19 patients with Class II malocclusion, 6 had a long face (vertical maxillary hyperplasia) with

bi-retrusion and open bite and 5 had a short face (vertical maxillary hypoplasia) with bi-retrusion. The remaining 8 patients exhibited mandibular hypoplasia with no associated vertical discrepancy.

Twenty-two patients had Class III skeletal malocclusion owing to sagittal maxillary hypoplasia and mandibular hyperplasia. Of these, 9 had a long face (vertical excess of anterior mandible), 6 had a short face (vertical

**Table 2. CHIEF COMPLAINT AND REFERRAL CONTEXT**

Chief complaint	
Desire for facial esthetic improvement	37
SDB	5
Malocclusion	3
Referral	
By orthodontist	22
Self-referred	23
Previous orthodontic treatment	
Yes	13
No	32

Abbreviation: SDB, sleep-disordered breathing.

*Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. Surgery First in Orthognathic Surgery. J Oral Maxillofac Surg 2013.*

**Table 3. MAIN DIAGNOSES**

Class II	
Vertical maxillary hyperplasia	6
Vertical maxillary hypoplasia	5
No vertical problems	8
Class III	
Vertical excess of the anterior mandible	9
Vertical maxillary deficiency	6
No vertical problems	7
Asymmetry	4

*Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. Surgery First in Orthognathic Surgery. J Oral Maxillofac Surg 2013.*



**Table 4. ORTHOGNATHIC PROCEDURES PERFORMED IN STUDIED SAMPLE**

Bimaxillary surgery	30
1-piece Le Fort I + BSSO	24
Segmented Le Fort I + BSSO	3
1-piece Le Fort I + BSSO + mandibular front-block osteotomy	2
Segmented Le Fort I + mandibular front-block osteotomy	1
Maxillary surgery	11
1-piece Le Fort I	8
Segmented Le Fort I	3
Mandibular surgery	4
BSSO	4

Abbreviation: BSSO, bilateral sagittal split osteotomy.

Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. *Surgery First in Orthognathic Surgery*. J Oral Maxillofac Surg 2013.

maxillary deficiency), and 7 had no vertical problems. Four patients presented with facial asymmetry. The main diagnoses of the studied sample are listed in Table 3.

#### SURGICAL PROCEDURE

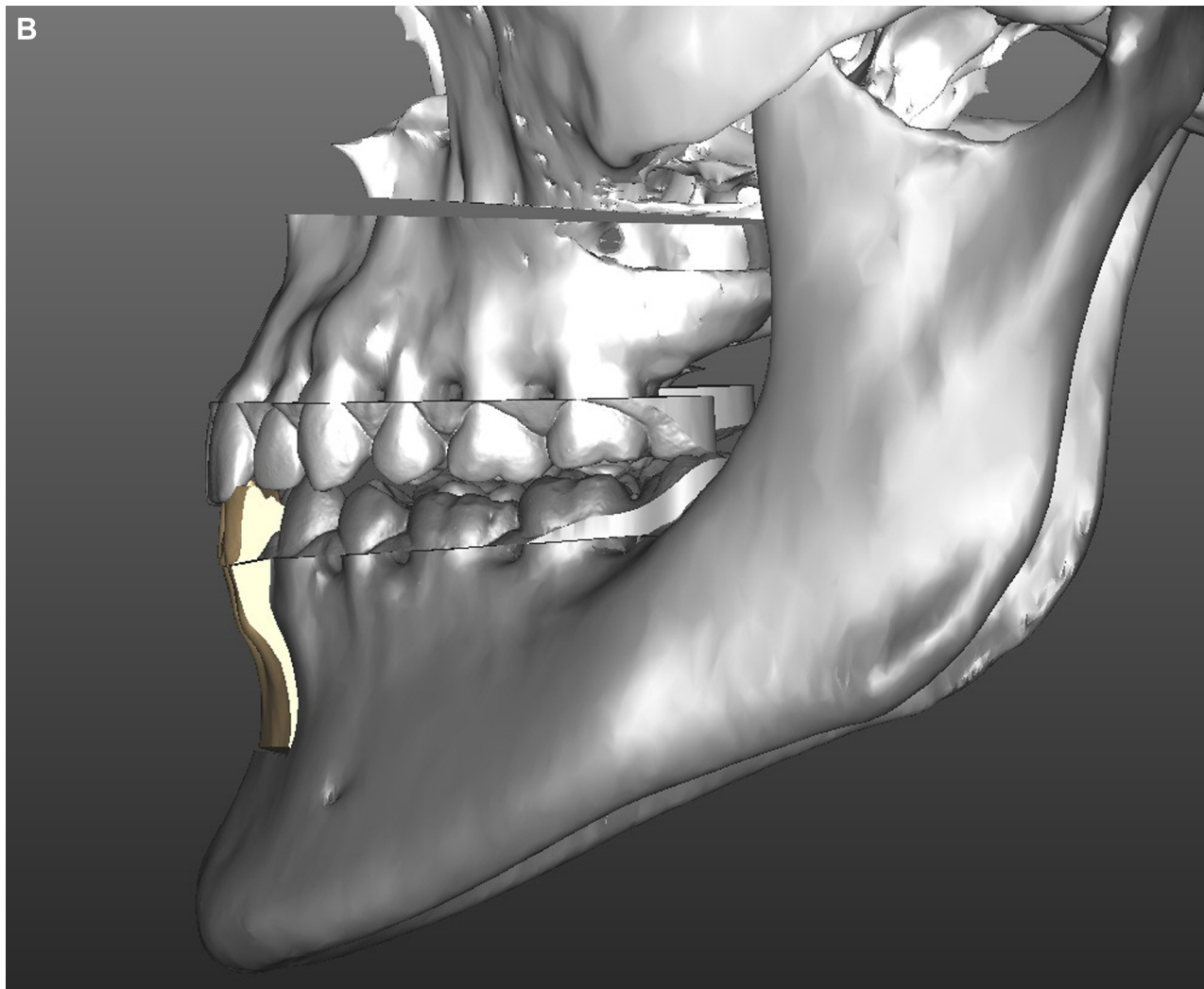
Orthognathic procedures are presented in Table 4. Bimaxillary surgery with a standard 1-piece Le Fort I osteotomy was the most common procedure (26 cases). Mandibular surgery was performed according to the sagittal split osteotomy design of Obwegeser<sup>16</sup> as modified by Dal Pont.<sup>17</sup> In addition, 3 patients received a mandibular front-block osteotomy for dental decompensation (Fig 4). Mean surgical time (from incision to last suture, excluding ancillary cosmetic procedures) was 84 minutes for a bimaxillary procedure (range, 63 to 125 minutes), 52 minutes for a maxilla-only procedure (range, 43 to 61 minutes), and 36 minutes for a mandible-only procedure (range, 29 to 46 minutes).

Together with the orthognathic surgical procedure, autogenous fat grafting was performed in 15 patients (malar augmentation in 9 cases, lip augmentation in 6). A simultaneous rhinoplasty was performed in 5 patients. Patients were discharged from the hospital in an average period of 17 hours (range, 1 to 24 hours). There was no need for blood transfusion. No postoperative infectious complications occurred. Similarly, no clinically evident iatrogenic fractures or significant neurovascular complications were noted.



**FIGURE 4.** Bimaxillary surgery with maxillary segmentation and mandibular front-block osteotomy. A, Preoperative occlusion. (Fig 4 continued on next page.)

Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. *Surgery First in Orthognathic Surgery*. J Oral Maxillofac Surg 2013.



**FIGURE 4 (cont'd).** B, Virtual planning of mandibular segmental osteotomy. (Fig 4 continued on next page.)

Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. *Surgery First in Orthognathic Surgery*. *J Oral Maxillofac Surg* 2013.

Ischemic necrosis of a central incisor was diagnosed at 1 week postoperatively in a case of maxillary segmentation with significant impaction.

#### ORTHODONTIC TREATMENT

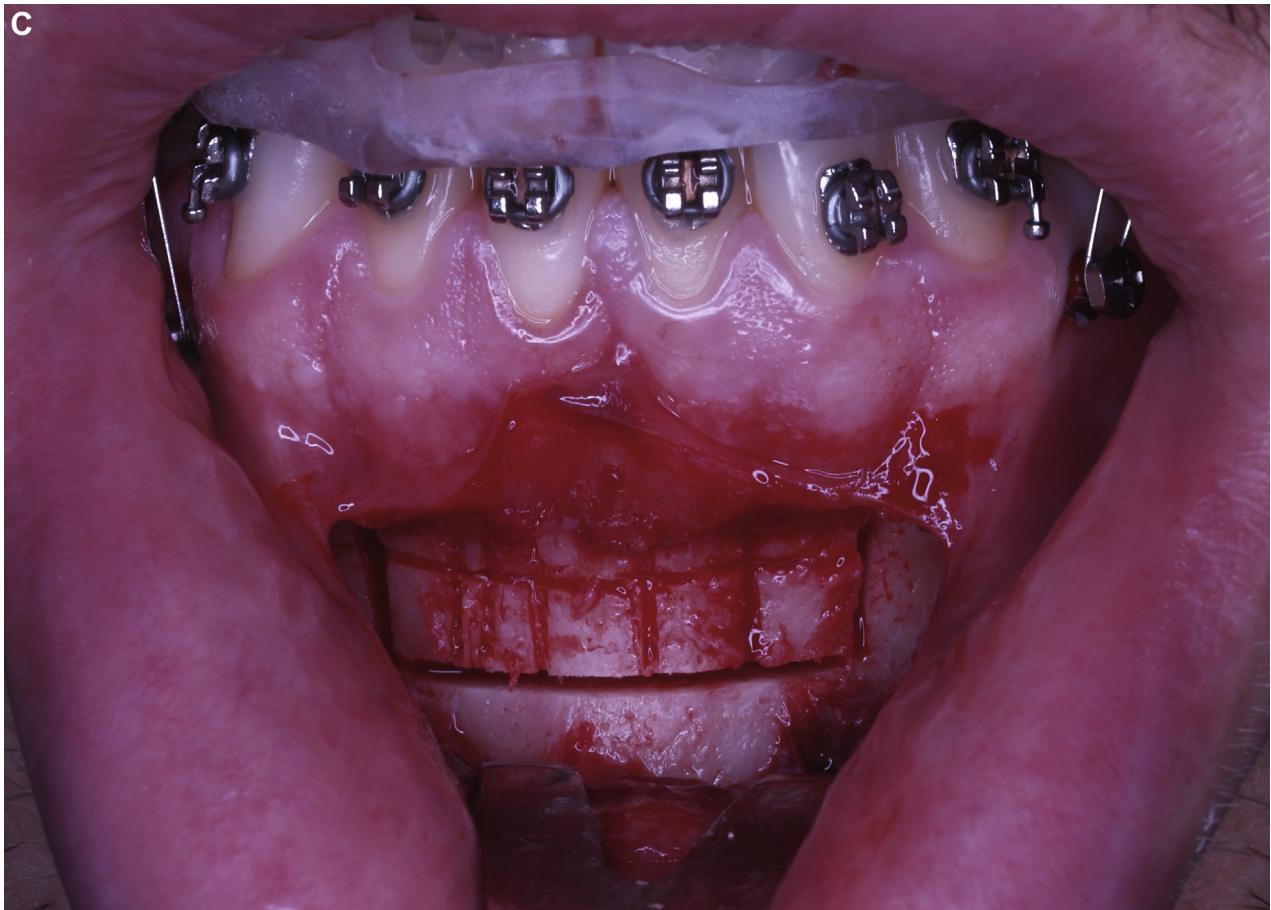
Mean duration of orthodontic treatment was 37.8 weeks (range, 24 to 52 weeks). Orthodontic retention was followed in all cases. An average of 22 orthodontic appointments (range, 14 to 29) occurred.

#### TREATMENT OUTCOME EVALUATION

Patient satisfaction at 12 months postoperatively was 9.4 on average (range, 8 to 10). Orthodontists' average satisfaction was 9.7 (range, 8 to 10). The 5 patients who had sought treatment based on sleep-disordered breathing were able to suspend nocturnal continuous positive airway pressure assistance at 6-month follow-up.

## Discussion

In recent decades, the number of orthognathic surgical patients with primarily esthetic concerns and time limitations against long treatments has increased significantly. Conventional orthognathic treatment usually entails long orthodontic phases of about 15 to 24 months preoperatively<sup>1-3</sup> and 7 to 12 months postoperatively<sup>1,2</sup> that cause significant patient discomfort.<sup>1,4,6</sup> Routine preoperative dental alignment, arch coordination, and incisor decompensation often tend to prolong treatment time, with little or no significant benefit for the patient.<sup>7</sup> In addition, preoperative axial correction of the incisors in patients with Class III skeletal malocclusion exacerbates a compensated anterior crossbite, thereby accentuating the prognathic profile and intensifying the patient's perception of facial disharmony.<sup>5</sup> Conversely, when surgery is performed before orthodontics, total treatment time is decreased noticeably.



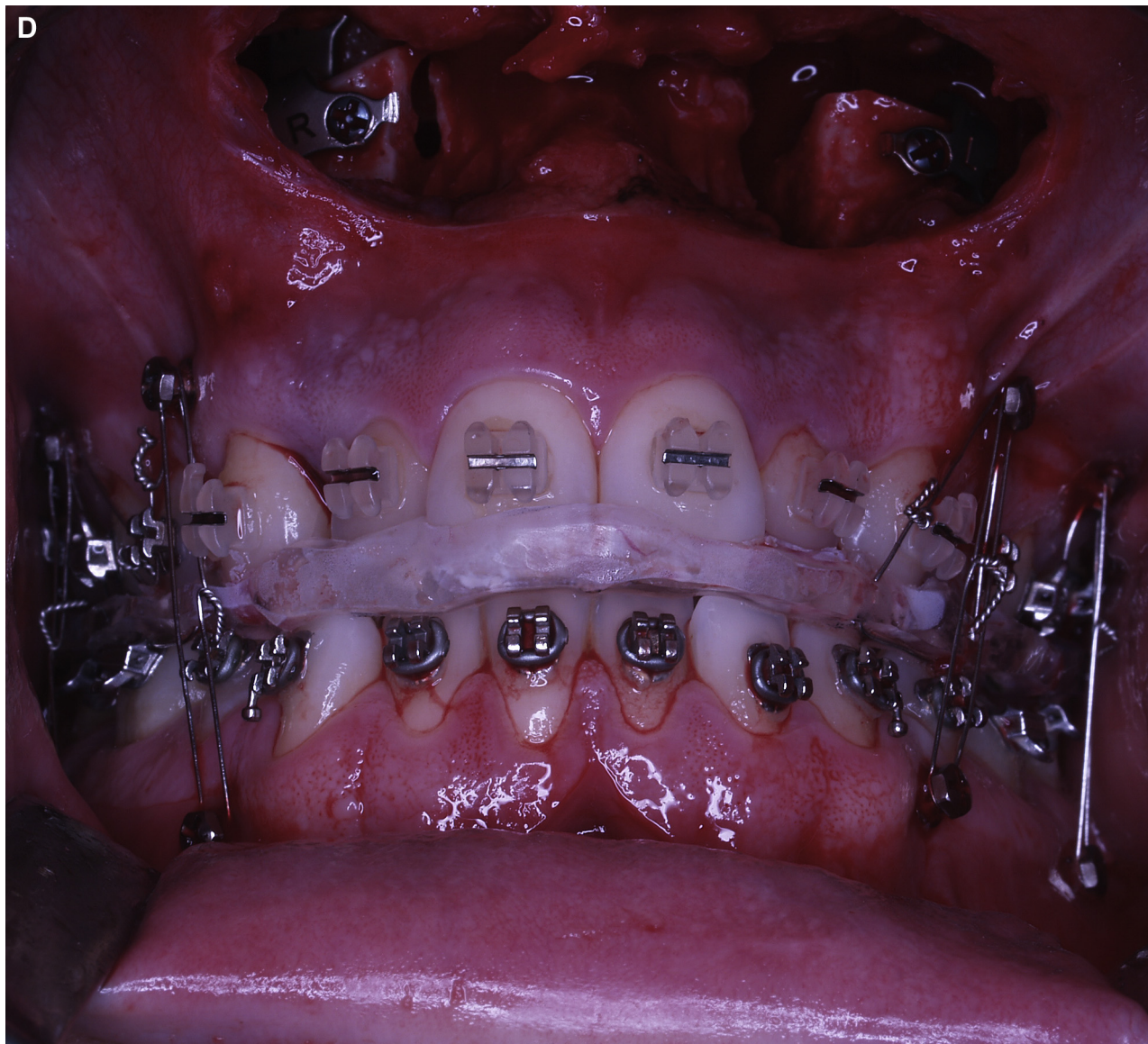
**FIGURE 4 (cont'd).** C, Intraoperative view of mandibular segmental osteotomy. The regional acceleratory phenomenon was enhanced with the execution of buccal corticotomies. (Fig 4 continued on next page.)

*Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. Surgery First in Orthognathic Surgery. J Oral Maxillofac Surg 2013.*

The skeletal problem (and therefore the esthetic concern) is corrected from the beginning.<sup>5,18</sup> This circumstance has a very positive influence in patients' compliance with postoperative orthodontics and is a powerful contributor to global satisfaction with treatment (Fig 5). Moreover, when sleep-disordered breathing (often at a stage of obstructive sleep apnea) is the main indication for treatment, early maxillomandibular advancement immediately increases the dimensions of the upper airway. As a result, the popularity of the SF concept in patients and their request for this approach when an orthognathic surgery procedure is foreseen are increasing steadily. Indeed, of 23 self-referred patients in the present study, 15 expressed their wish for an SF approach.

Moreover, the acceptance of an SF approach in the orthodontist community is increasing gradually. According to the present results, orthodontists' appreciation of the overall treatment outcome (VAS average, 9.7) was even slightly better than the patients' perception (VAS average, 9.4). This is an important fact to highlight, because

the orthodontic management of an SF case can be very technically demanding. First, the patient's baseline occlusion cannot serve as a guide for the designation of treatment goals.<sup>5</sup> This means that the underlying skeletal abnormalities must be assessed accurately in 3 dimensions to establish an effective treatment plan. The orthodontist must be able to foresee the extent and limitations of potential orthodontic movements. Second, immediate postoperative occlusion is often unstable, especially in segmented maxillas, so the end splint must be left in place for 2 to 3 weeks postoperatively. Because orthodontic treatment must start as soon as possible (often 2 weeks after surgery), the orthodontist must be ready to follow the patient closely. Third, the orthodontist must be experienced in the use of temporary anchorage devices, such as miniscrews and miniplates,<sup>19</sup> which are used routinely in this protocol. These devices play a key role in anchoring orthodontic forces so that any required vector can be used.<sup>5</sup> They also can help compensate for surgical error or skeletal relapse.<sup>7</sup> Fourth, the fact that orthodontic treatment is shortened to an



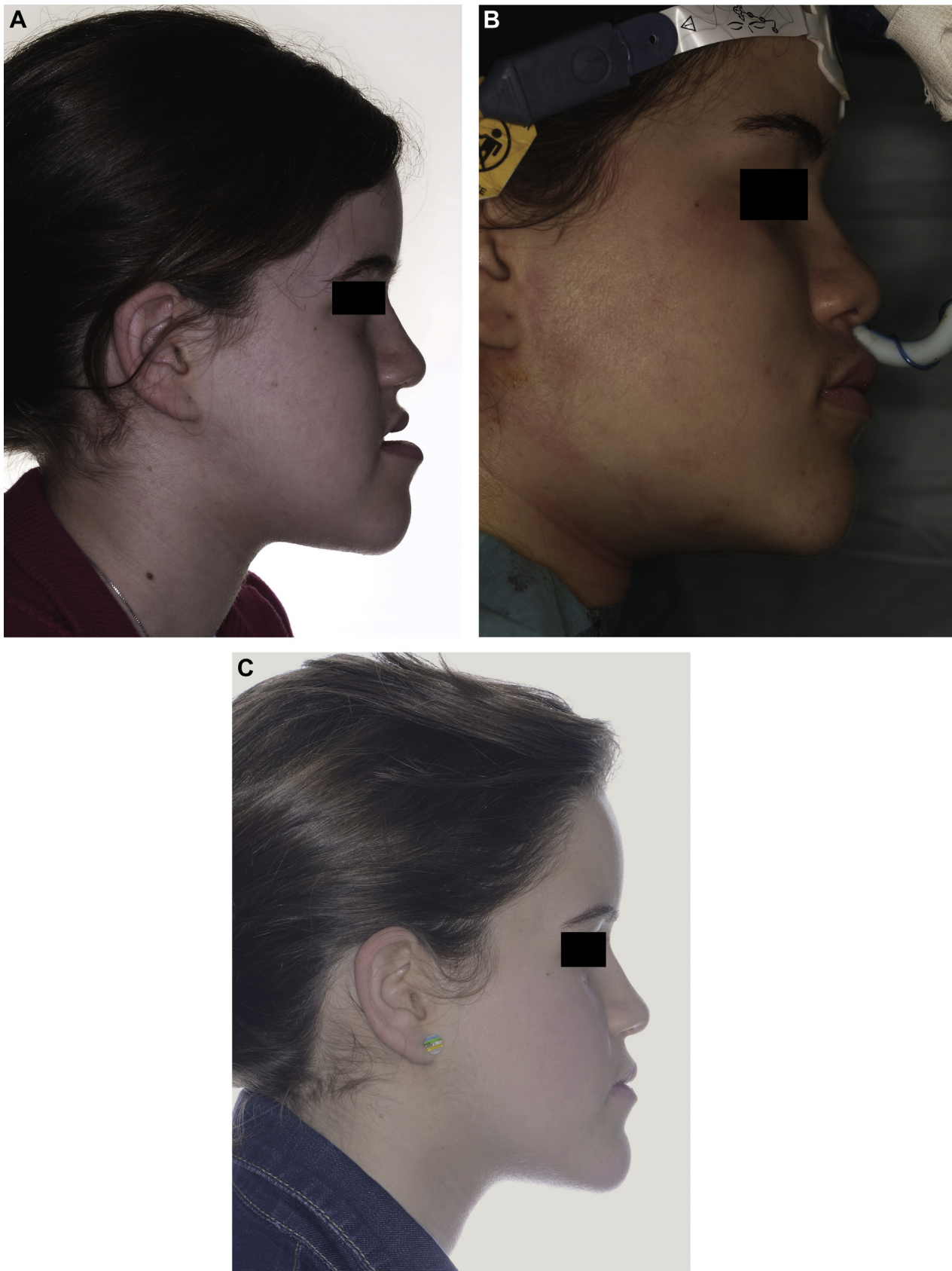
**FIGURE 4 (cont'd).** D, Final occlusion with end splint. Eight transmucosal 2.0-mm miniscrews were used to stabilize the occlusion. These were placed between the canines and the first premolars and between the second premolars and the first molars. The front segment of the segmented maxilla was not fixated with osteosynthesis material to allow for precise vertical control of the postoperative overbite.

*Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. Surgery First in Orthognathic Surgery. J Oral Maxillofac Surg 2013.*

average of 37.8 weeks implies that dental movements are significantly expedited. This improved efficiency of orthodontic forces is significantly related to the process of demineralization and remineralization consistent with the wound-healing pattern of the RAP.<sup>5,9,10,20-23</sup> Together with the orthognathic procedure, selective bone injury through the performance of buccal corticotomies enhances the activating stimulus for the RAP in the periodontium.<sup>5,10</sup> As a result, orthodontic appointments must be scheduled more often than in a conventional treatment approach. According to the present results, an average of 22 orthodontic

appointments was performed, for a mean total treatment time of 37.8 weeks. In other words, the latency period between every archwire change is approximately 2 weeks. This treatment tempo may be somewhat stressful for the orthodontist. Nevertheless, it provides the patient with a comfortable feeling of constant surveillance.

From a surgical point of view, an SF protocol does not necessarily entail greater technical complexity. In the authors' experience, mean surgical time was 84 minutes for a bimaxillary procedure, and all monomaxillary surgeries (including maxillary segmentation)



**FIGURE 5.** A, Preoperative, B, immediate postoperative, and C, final views of a patient with Class III malocclusion treated with a surgery-first approach. Orthodontic preoperative axial correction of the inferior incisors was not performed to avoid exacerbating the anterior crossbite. The patient greatly valued the immediate esthetic improvement.

*Hernández-Alfaro, Guijarro-Martínez, and Peiró-Guijarro. Surgery First in Orthognathic Surgery. J Oral Maxillofac Surg 2013.*

were performed within 1 hour. Some researchers have claimed that miniplate placement increases surgical time by an average of 10 to 15 minutes per plate.<sup>9</sup> The present study did not separately quantify the time needed for temporary anchorage device placement, but subjectively it did not seem to influence average total surgical time substantially. All surgeries were performed according to the authors' previously described minimally invasive protocol for orthognathic surgery.<sup>13</sup> In the maxilla, the key points of this methodology are a limited incision from canine to canine and frontal pterygomaxillary dysjunction. In the authors' opinion, a systematic procedure with minimal soft tissue debridement is essential to minimize postoperative morbidity.

Regarding postoperative stability, Nagasaka et al<sup>7</sup> proposed the routine use of an occlusal splint while eating. However, the authors did not observe increased instability without this *modus operandi*. According to the authors' current protocol, only in cases of maxillary segmentation is the end splint left in place for 2 weeks.

Despite the evident advantages of an SF approach, it is unquestionable that careful patient selection, detailed treatment planning, and constant communication between the surgeon and the orthodontist are absolutely indispensable.<sup>5</sup> According to the authors' protocol, patients with TMJ symptoms or uncontrolled periodontal disease are automatically excluded from an SF approach based on an unstable postoperative occlusion or demanding orthodontic movements, respectively. Regarding the type of dentofacial anomaly, Liou et al<sup>8,10</sup> restricted their indications to cases that did not need too much presurgical orthodontic alignment and decompensation; in other words, cases with well aligned to mildly crowded anterior teeth, flat to mild curve of Spee, and normal to mildly proclined or retroclined incisors. In agreement with Liou et al, the present protocol excludes patients with severe crowding requiring extractions and cases of Class II Division 2 malocclusion with overbite, that is, cases in which the curve of Spee is severely altered. Moreover, cases requiring SARPE to achieve an adequate transverse maxillary dimension or severe asymmetries with 3D dental compensations are currently excluded from the SF protocol. In the authors' opinion, these scenarios seem to be too complex and inaccurate to anticipate the final occlusion accurately. Moreover, 3D dental compensations can significantly impair immediate postsurgical stability. The authors prefer a conventional approach for cases managed by an orthodontist with limited experience in orthognathic surgery. Although the current exclusion criteria may seem rather extensive, the authors expect to gradually

broaden the indications for the SF approach as their experience increases and current limitations become reasonably controlled.

To the authors' knowledge, this study presents the first prospective large-sample series of orthognathic surgical patients treated with an SF approach. Based on the benefits and pitfalls of this treatment concept, a standardized protocol for diagnosis, surgical and orthodontic execution, and specific inclusion and exclusion criteria are proposed. In the context of careful patient selection, precise treatment planning, and fluent bidirectional feedback between the surgeon and the orthodontist, the SF approach significantly decreases total treatment time and achieves high levels of patient and orthodontist satisfaction. Therefore, it may represent a reasonable alternative for a large proportion of patients.

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