Int. J. Oral Maxillofac. Surg. 2015; 44: 752–759
http://dx.doi.org/10.1016/j.ijom.2015.01.022, available online at http://www.sciencedirect.com

International Journal of Oral & Maxillofacial Surgery

Clinical Paper
Orthognathic Surgery

Cephalometric analysis and long-term outcomes of orthognathic surgical treatment for obstructive sleep apnoea

E. D. Ubaldo, G. M. Greenlee, J. Moore, E. Sommers, A.-M. Bollen
Department of Orthodontics, School of Dentistry, University of Washington, Seattle, WA, USA

E.D. Ubaldo, G.M. Greenlee, J. Moore, E. Sommers, A.-M. Bollen: Cephalometric analysis and long-term outcomes of orthognathic surgical treatment for obstructive sleep apnoea. Int. J. Oral Maxillofac. Surg. 2015; 44: 752–759.

Abstract. The aim of this study was to describe skeletal and posterior airway changes after orthodontic treatment and surgical jaw advancement, and to evaluate whether there is a correlation between increasing advancement and a long-term reduction in obstructive sleep apnoea (OSA). Lateral cephalograms and polysomnography (apnoea–hypopnoea index, AHI) were collected from patients treated with bilateral sagittal split osteotomy (BSSO) or maxillomandibular advancement (MMA) in combination with orthodontics. Patients completed a questionnaire and the Epworth Sleepiness Scale (ESS) to assess long-term outcomes. Descriptive statistics for cephalometric measurements and linear regression were performed to find estimates of the final OSA (AHI and ESS) as a function of mandibular advancement. Forty-three patients with surgical advancement of the maxilla (5.2 mm) and mandible (8.3 mm) had a 4-mm increase in posterior airway. Thirty-three patients completed the long-term survey (6.3 ± 2.6 years after treatment); 91% reported a reduction of OSA and were pleased with their facial appearance. The maxillomandibular and posterior airway increased. There was no evidence of a linear relationship between greater amounts of mandibular advancement and improvement of OSA. Patients with less than 10 mm advancement had successful objective short-term and subjective long-term OSA reduction.

Key words: obstructive sleep apnoea; surgical jaw advancement; orthodontics; cephalometry.

Accepted for publication 28 January 2015
Available online 18 February 2015

The surgical management of obstructive sleep apnoea (OSA) has evolved over the last decade and often includes orthodontics for coordination and stabilization. A systematic review in 2010 recommended larger maxillomandibular advancement (MMA) for more predictable surgical success,[1] a concept based on the initial findings of Riley et al. in 2000.[2] In this landmark study, a positive correlation was found with the amount of advancement and clinical improvement based on polysomnography results.[2] The study reported a clinically significant difference in the amount of advancement when separating patients based on improvement in Respiratory Disturbance Index (RDI), and the authors concluded that 10 mm of advancement should be considered the surgical standard.[2,3]

This 10 mm value has become the gold standard and the minimum amount of mandibular advancement that providers should strive to achieve in patients with OSA. However, this value is based on one relatively small study where patients did not undergo orthodontic treatment in conjunction with the surgical procedures, possibly reducing the long-term stability. The correlation between the amounts of surgical advancement and long-term reduction of sleep apnoea remains unclear. Clinical studies have shown a reduction of apnoea–hypopnoea index (AHI) scores in the short-term follow-up of 6–9 months, but long-term clinical results are unknown. In a recent cohort study with an 8-year follow-up, patients who underwent 8 mm of MMA showed significant, stable reduction of AHI. The improvements in OSA symptoms were achieved without the preferred 10 mm advancement. However, the study had a small sample.[4]

The purpose of this study was to describe the posterior airway space changes in patients undergoing orthodontics and single or dual surgical jaw advancement, and to evaluate if there is a correlation between increasing amounts of advancement and a long-term reduction in OSA.

Materials and methods

The orthognathic surgical records of one oral surgeon and of one orthodontist were searched for all OSA patients treated (independent of outcome) with orthodontics and surgical jaw advancement from 1995 to 2010. A sleep apnoea diagnosis code in the electronic health record identified patients eligible for the study. Once patients were identified, an attempt was made to collect the cephalometric films from the oral surgeon and/or orthodontist who had overseen the completed treatment.

The following inclusion criteria were used: (1) Diagnosis of OSA prior to orthodontic treatment, as diagnosed by initial sleep study results (RDI >20 or AHI >20). (2) Treatment with orthodontics in conjunction with bilateral sagittal split osteotomy (BSSO) advancement or MMA osteotomies. (3) Cephalometric films available for four time-points: T1, the initial/pre-orthodontic film; T2, presurgical film (taken within 3 weeks before the surgery); T3, post-surgical film (taken on average 5 days post-surgery); T4, appliance removal/end of active orthodontics film (taken on average 13 months after the surgery).

Exclusion criteria were incomplete, illegible, or non-diagnostic radiographs, and pre-treatment history of facial trauma, facial surgery, or any syndrome affecting the face. Human subjects approval for this study was obtained from the institution's human subjects divisions.

Study identification numbers for each cephalometric film replaced all patient identification information. Conventional cephalometric films were scanned with an Epson Expression 1680 scanner (Epson, Long Beach, CA, USA) at 200 dpi and captured into Dolphin Imaging Software version 11.0 (Dolphin Imaging and Management Solutions, Chatsworth, CA, USA) for measurement. When digital films or images taken on the 3dMD system (3dMD, Atlanta, GA, USA) were available, they were captured and converted into a two-dimensional (2D) lateral cephalogram for consistency.

All cephalometric radiographs were digitized and traced by the same examiner. The examiner was blinded to the subject's identity; however, the presence of malocclusion, appliances, and fixation allowed the examiner tracing the film to be aware of the temporal sequence of the T1, T2, T3, and T4 films. The following orthodontic and skeletal landmarks were identified (Fig. 1): sella (S), nasion (N), porion (Po), orbitale (Or), posterior nasal spine (PNS), A-point (A), B-point (B), gonion (Go), maxillary incisor tip (U1T), maxillary molar mesiobuccal cusp tip (Mx MBT), mandibular incisor tip (L1T), mandibular molar mesiobuccal cusp tip (Mn MBT) (Fig. 1). The following reference lines were made on all tracings in order to create the descriptive linear and angular measurements of interest (Fig. 1): constructed horizontal plane (S–N line, 7°) and x-axis (vertical at S, perpendicular to constructed horizontal plane).

The descriptive linear and angular cephalometric film measurements made at each time interval included the following (Fig. 1): overjet (OJ), posterior airway space (PAS; distance between the base of the tongue and the posterior pharyngeal wall, derived from a line connecting B-point to Go in millimetres), x-axis to PNS (PNSx; from the constructed vertical to PNS in millimetres, describes the horizontal position of the maxilla), x-axis to B-point (Bx; from the constructed vertical to B-point in millimetres, describes the horizontal position of the mandible).

To measure the skeletal changes throughout treatment, the difference was calculated for each of the descriptive measurements of PAS, PNSx, and Bx. The differences were calculated for each of the following time periods: T1–T2, T2–T3, T3–T4, and T1–T4. The measured changes from T2–T3 verified the surgical advancement of the maxilla and/or mandible. The changes from T3–T4 demonstrated any post-surgical relapse and dentoalveolar corrections or compensations. The changes from T1–T4 demonstrated the overall skeletal changes throughout treatment.

All linear measurements were corrected for magnification. Cephalometric films possessing rulers or some magnification scale were adjusted accordingly. For films not possessing rulers, magnification was adjusted by using the length of the sella–nasion line in millimetres and calibrated in Dolphin, as the cranial base is considered relatively stable beyond 7 years of age.[5]

Survey

All patients identified for the retrospective cephalometric study were recruited to participate in an online survey. The survey assessed the long-term results of the OSA treatment. In addition to the Epsworth Sleepiness Scale (ESS), questions were asked regarding current height and weight, improvement in OSA, whether further treatment was obtained, whether they were pleased with their facial appearance, and whether they would recommend the surgery to others (see Fig. 2). Contact information was collected during the initial screening of records, along with the age, height, weight, gender, pretreatment start date, date of surgery, date of fixed orthodontic appliance removal, Angle classification, and initial and final polysomnography reports.

Subgroups

The 'total sample' comprised the total number of patient records that were identified and met the inclusion criteria. The 'cephalometric subsample' comprised the subgroup of patients for whom all four lateral cephalograms were available. The 'survey subsample' consisted of those patients who returned the long-term survey questionnaire. The 'ESS subsample' included patients with all four lateral cephalograms, who also returned the long-term survey questionnaire. The 'AHI subsample' comprised patients with all four lateral cephalograms and both initial and final sleep study analyses (AHI index).