HHS Public Access

Author manuscript

J Oral Maxillofac Surg. Author manuscript; available in PMC 2017 October 01.

Published in final edited form as:

J Oral Maxillofac Surg. 2016 October ; 74(10): 2033–2043. doi:10.1016/j.joms.2016.04.005.

Morbidity and Mortality Rates after Maxillomandibular Advancement for Treatment of Obstructive Sleep Apnea

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Abstract

Purpose—To compare morbidity and mortality rates in obstructive sleep apnea (OSA) versus dentofacial deformity (DFD) patients undergoing equivalent maxillofacial surgical procedures.

Patients and Methods—Patients with OSA who underwent maxillomandibular advancement with genial advancement (MMA), at Massachusetts General Hospital Department of Oral and Maxillofacial Surgery, from December 2002 to June 2011, were matched to patients with DFD undergoing similar maxillofacial procedures during the same time period. They were compared with regards to demographic variables, medical comorbidities, perioperative management, intraoperative, early and late postoperative complications and mortality.

Results—A study group of 28 patients with OSA and a control group of 26 patients with DFD were compared. The patients with OSA were older (41.9±12.5 vs. 21.7±8.6years), had a higher ASA classification (2.0±0.5 vs. 1.3±0.6) and BMI (29.6±4.7 vs. 23.0±3.1kg/m^2). They also had a greater number of medical comorbidities (2.4±2.3 vs. 0.7±1.0). More OSA than DFD patients had complications (28, 100% vs.19, 73%, p=0.003) and the total number of complications in the OSA

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Conflict of Interest Disclosures: None of the authors reported any disclosures.

group was higher (108 vs. 33, $p<0.001$). In the OSA group, 13.9% and in the DFD group 3.0% of the complications were classified as major. The absolute risk of a complication for the OSA group was 3.9 vs . 1.3 for the DFD group. The relative risk of complications in OSA compared to DFD was 3.0. No difference in mortality was found.

Conclusions—OSA patients were older, had more comorbidities and ultimately had a greater number of early, late, minor and major complications than those in the DFD group. The incidence of mortality in both groups was zero. MMA appears to be a safe procedure with regards to mortality but OSA patients should be counseled preoperatively regarding the relative increased risk of complications.

INTRODUCTION

Surgical procedures devised to treat one particular condition can, at times, be applied to the treatment of others involving the same anatomic area. The Roux-en-Y procedure, while initially described as a method for bypassing gastric obstruction secondary to peptic ulcer scarification is now frequently employed in bariatric surgery to facilitate weight loss[1]. In a similar fashion, orthognathic surgical procedures such as Le Fort 1 and bilateral sagittal split osteotomies, which were originally described for correction of congenital and acquired dentofacial deformities (DFD), are now frequently employed for treatment of obstructive sleep apnea (OSA). Multiple investigators have demonstrated that orthognathic surgery is safe and predictable with relatively low morbidity and rare mortality[2-4]. In addition, perioperative predictor variables such as operating time, hospital length of stay and blood loss have been defined[5-8].

Maxillomandibular advancement (MMA) is one of the most effective surgical treatments for OSA, with well documented favorable and stable results.[9-14] Preoperative evaluation and perioperative risk assessment may differ in the OSA cohort compared to the DFD cohort. In previous surgical studies, OSA patients were more likely to have several common comorbidities including cardiac and vascular disease, hypertension[15-20], congestive heart failure and stroke[17,18]; dyslipidemia[17] and diabetes[17] than the general population. Most of these comorbidities are related to obesity[17-19,21] and associated with increased risk of perioperative and postoperative complications[22].

Complication rates have been reported in OSA patients undergoing bariatric[23-25], cardiac[26], and orthopedic[27] operations. Similarly, complication rates have been described in OSA patients undergoing upper airway procedures such as uvulopalatopharyngoplasty[28,29]. The most common complications detailed in previous studies are atelectasis[22], pulmonary embolism[22,24], dysrhythmia[22,24,26,30], hypoxemia[22,30-32], hypotension[22,30], chest pain[22], myocardial infarction[30,32], and death[24-26]. These complications subsequently lead to unplanned ICU transfers, longer hospital stays, and readmissions[31,32].

We hypothesize that morbidity rates would be significantly different in OSA compared to DFD patients but that mortality rates would be equal and low. The aims of this study are to compare morbidity and mortality rates in OSA and DFD patients undergoing equivalent maxillofacial procedures and to document demographic and disease related variables that contribute to any differences that exist.

Materials and methods

Subjects

This was a retrospective cohort study of all adult patients who underwent maxillary and mandibular osteotomies with a genioplasty or genial tubercle advancement in the Department of Oral and Maxillofacial Surgery at Massachusetts General Hospital (Boston, MA) between December 2002 and June 2011. The department surgical log and hospital billing systems were searched to identify patients undergoing the above procedures for treatment of OSA (study group) and those undergoing the procedures for DFD (control group). Inclusion criteria were 1) completion of a single-piece Le Fort I osteotomy, bilateral sagittal split mandibular osteotomies and either a genial tubercle advancement or genioplasty, 2) adequate clinical documentation and 3) a diagnostic polysomnogram for patients undergoing MMA for treatment of OSA. Exclusion criteria for both groups were 1) previous orthognathic surgery, 2) other previous maxillofacial surgery, 3) presence of craniofacial syndromes, 4) history of cleft lip and palate, 5) inadequate clinical documentation and 6) active temporomandibular dysfunction. Patients undergoing orthognathic surgery for treatment of a DFD were excluded if they carried a diagnosis of OSA that was not being addressed by the maxillofacial procedure. This study was approved by the Institutional Review Board for Human Studies of the Massachusetts General Hospital (Protocol #: 2011P001403).

Study Variables

The data collected were grouped into preoperative, intraoperative and postoperative variables.

Preoperative variables consisted of age, gender, ASA (American Society of Anesthesiologists) classification, and body mass index (BMI). The comorbidities were documented as medical problems (e.g. obesity, diabetes, hypertension, cardiac disease, etc.), history of cancer, number of regularly prescribed medications in use, previous operations, and use of tobacco, alcohol, and/or illicit drugs.

Intraoperative variables included, but were not limited to, number of intubation attempts, time to intubation, presence of difficult airway, the use of hypotensive anesthesia, steroids, and antibiotics, length of the procedure, estimated blood loss, and type of intraoperative intermaxillary fixation (IMF) applied.

Postoperative variables included, but were not limited to, use of antibiotics, length of stay, and number of scheduled postoperative visits. A comprehensive listing of all study variables investigated and their definitions can be found in Appendix 1.

Complications

Complications studied were grouped, based on time of occurrence, as intraoperative or postoperative complications. Intraoperative complications included number of intubation attempts, the necessity to redo rigid fixation, witnessed trigeminal nerve injuries, unfavorable or unplanned osteotomies, and unplanned need for postoperative IMF.

Postoperative complications studied included, but were not limited to, medical events, infections, dental injuries and malocclusion, nasal septum deviation, wound dehiscence, epistaxis, loss of fixation, nonunion, dysphagia, dysphonia, velopharyngeal insufficiency, persistent trigeminal nerve dysfunction, temporomandibular joint (TMJ) and myofascial pain, number of unplanned outpatient follow-up visits, and unplanned communications between surgeon and patient.

Postoperative complications were then further divided into early (those occurring from end of procedure until 3 months after discharge) and late (occurring >3 months after discharge). These complications were also stratified into major and minor events. Major complications were defined as any complication requiring readmission and/or operation under general anesthesia. All other complications were considered minor. A comprehensive listing of all complications investigated and their definitions can be found in Appendix 2.

Statistical Analysis

Statistical analysis was done with SPSS (v.22.0 for Mac, SPSS Inc., Chicago, IL). The *p*-values were calculated by t-test for numerical, Chi Square or Fisher's exact test for nominal, and Wilcoxon-Mann-Whitney's test for ordinal variables. For all variables $p \leq 0.05$ was considered statistically significant. Pearson's or Spearman's correlation analysis was performed to determine the relationship between pre, intra and postoperative variables.

Results

Between December 2002 and June 2011, a total of 976 patients underwent orthognathic surgery in the Department of Oral and Maxillofacial Surgery at the Massachusetts General Hospital. Of this, a total of 97 patients underwent exclusively a Le Fort I osteotomy, mandibular sagittal split osteotomy and genioplasty or genial tubercle advancement during the same operation. Fifty-four of the 97 patients met the strict inclusion and exclusion criteria. Twenty-eight patients (5 females and 23 males) made up the study group while the remaining 26 patients (20 females and 6 males) composed the control group. The most common reason subjects were excluded from the study were completion of multi-piece Le Fort I osteotomies, insufficient documentation, or presence of other craniofacial syndromes.

Study Variables

Preoperative characteristics of both groups are presented in Table 1. The mean age of the study group was 41.9 (±12.5) years and included 2 patients who were active smokers and 5 who had a history of smoking. Twelve of the study group patients reported social use of alcohol, and 1 used illicit drugs. In this same group, 2 patients had history of cancer. The mean age of the control group was 21.7 (±8.6) years and included 1 patient who was an active smoker, and 5 who reported social use of alcohol.

Intraoperative characteristics of both groups are presented in Table 2. There was no statistically significant difference between the two groups with regards to intraoperative management. All patients in both groups had hypotensive anesthesia, received intraoperative steroids and prophylactic antibiotics. Of the 28 OSA patients, 6 were classified as having a difficult airway, invasive monitoring was used in 1, and 15 required use of vasopressor

medications. Of the 26 DFD patients, 1 was classified as having a difficult airway, invasive monitoring was not used in any of the patients and 9 required use of vasopressor medications.

Only 4 of the 28 OSA patients had preoperative placement of orthodontic appliances for tooth alignment and for intraoperative maxillomandibular fixation (IMF). Intraoperative IMF was achieved with arch bars (n=14) or skeletal screws (n=10) in the remaining patients. In the control group, intraoperative IMF was achieved using only the orthodontic appliances (n=20), while 6 patients had orthodontic appliances plus skeletal screws.

Postoperative characteristics of both groups are presented in Table 3. The study group follow-up ranged from 44 days to 74.5 months, with an average of 453 days (± 460.3 days), and the control group was followed from 47 days to 64.1 months, with an average of 475.3 days (± 495.2 days), p=0.86. During the postoperative period, only 2 variables differed significantly between the two groups. The length of stay was greater for the OSA group (2.4 ± 0.8 days) than the DFD group (1.9 ± 0.8 days), p=0.02, and the number of extra analgesic prescriptions required was also greater for the OSA group (1.0 ± 1.0 prescription) than the DFD group (0.2 ± 0.4 prescriptions), p=0.001.

Complications

There was no statistically significant difference between the two groups with regards to intraoperative complications. Seven patients of the OSA group, and 5 patients of the DFD group required more than one intubation attempt. Only one patient, in the DFD group, required reapplication of rigid fixation. Four patients had a witnessed injury of the mandibular nerve, 1 in the DFD group and 3 in the OSA group. An unfavorable osteotomy occurred in one patient of each group but only 1 patient, in the OSA group, needed to be kept in unplanned IMF postoperatively.

The number of patients experiencing postoperative complications was greater in the OSA group than the DFD group (28 vs. 19 patients, p=0.003). All of the postoperative complications studied occurred more frequently in the OSA group than the DFD group with the exception of nasal septum deviation, and dental injury, both of which occurred equally between the groups. The postoperative complications that were significantly more frequent in the OSA than the DFD group were dysesthesia (6 vs. 0 patients, p=0.024), infection (18 vs. 6 patients, p=0.002), hardware removal (11 vs. 0 patients, p<0.001) and reoperation (9 vs. 0 patients, p=0.002). There were more occurrences of epistaxis, complaints of unaesthetic results, paresthesia, TMJ pain and myofascial pain in the DFD group than the OSA group, but only TMJ pain was found to be statistically significant (4 vs. 0 patients, p=0.047) (Table 4).

The total number of postoperative complications in the OSA group (108) was significantly higher than the total number of complications in the DFD group (33, p<0.001). The absolute risk (AR) of experiencing a postoperative complication in the OSA group was 3.86 and in the DFD group 1.27. The OSA group had a relative risk (RR) of complications when compared to the DFD group of 3.04.

Analysis of postoperative complications, using time as an independent variable, was completed (Table 4). Hardware removal was the only postoperative complication that occurred during both the early and late timeframes with significance (early, $p<0.05$ and late, $p<0.002$). Complications that occurred only during the early postoperative timeframe with significance were dysesthesia (early, $p=0.05$ vs. late, $p=0.09$), infection (early, $p=0.001$ vs. late, $p=0.17$), and velopharyngeal insufficiency (early, $p<0.02$ vs. late with no occurrences). The complication that occurred only during the late postoperative timeframe with significance was reoperation (early, $p=0.17$ vs. late, $p<0.003$).

Major complications, as defined above, occurred more frequently in the OSA group (12 total, AR 0.43) than the DFD group (1 total, AR 0.04), resulting in a RR of experiencing a major complication of 10.75 for OSA patients. Infection accounted for all major complications in both groups.

Correlation between Study Variables and Complications

The Pearson correlation analysis was used to compare all variables and complications. Variables and complications that were moderately (R between 0.3 and 0.5) to strongly correlated (R higher than 0.5) and statistically significant ($p<0.05$) are detailed in Table 5. Current smoking was strongly correlated with loss of fixation (R=0.57, $p<0.01$) and moderately correlated to non-union (R=0.38, $p<0.01$). History of smoking was moderately correlated to the number of prescribed medications (R=0.34, $p<0.05$), infection (R=0.32, $p<0.05$), hardware removal (R=0.31, $p<0.05$), loss of fixation (R=0.33, $p<0.05$), and to an increase in the intubation time (R=0.34, $p<0.05$). Infection was moderately correlated with the number of unplanned communications (R=0.45, $p<0.01$). Length of stay was found to be strongly correlated with ASA status (R=0.52, $p<.001$).

Discussion

MMA has been shown to be an effective surgical treatment for patients suffering from OSA[9-14]. The procedures used to advance the maxillomandibular complex in OSA patients are the same as those employed for correction of dentofacial deformities. The safety of orthognathic surgery has been previously established[2-4]. Initial studies have shown MMA to be a safe treatment[11,33] but a detailed comparison of outcomes experienced by OSA and DFD patients undergoing the same procedures has yet to be published.

While the procedures used to treat OSA and DFD may be very similar, the same cannot be said of OSA and DFD patients. The study and control groups all had the same surgical interventions and were followed for the same period of time. Similar to previously published findings[11,16,17,34], OSA patients in the current study were older, predominantly male, had higher ASA status and BMI, more medical comorbidities, used more prescription medications and had had more previous operations than the DFD cohort.

It is important to note that the primary aim of this study was to compare two groups of patients undergoing similar surgical interventions. However, the specifics of the operations were not exactly equivalent in terms of magnitude of advancement or complexity of the movements. The OSA group would be expected to have a greater amount of advancement in

the sagittal plane alone. In contrast, the DFD group, where occlusal changes were part of the treatment, likely had greater complexity of movements in 3 dimensions, with less overall advancement. Review of the two groups in this study confirm this assumption. Maxillary advancement in the DFD group ranged from 2-9mm with an average of 5mm (± 2.1mm) vs. 6-15mm in the OSA group with an average of 10mm (± 1.6mm). Mandibular sagittal movement in the DFD group ranged from 0-12mm with an average of 6mm (±3.2) vs. 9-15mm in the OSA group with an average of 11.6mm (±1.8mm). Intuitively, it may seem obvious that greater magnitudes of MMA would lead to more complications and poorer skeletal stability than smaller advancements. However, data from published studies demonstrate, no decrease in skeletal stability is associated with the large advancements seen in OSA patients[35] and that velopharyngeal insufficiency is not associated with the amount of maxillary advancement in cleft lip and palate patients[36]. Additionally, it has been shown that the magnitude of mandibular advancement and age alone do not correlate with changes in neurosensory outcomes following bilateral sagittal split osteotomies. It has been demonstrated that patients older than 35 who undergo a genioplasty along with bilateral sagittal split osteotomies (as opposed to bilateral sagittal split osteotomies alone) will have greater neurosensory deficits than those younger than 35.[37] In our patient cohorts, the majority of the OSA patients had genial tubercle advancement and not a genioplasty. Age has also previously been shown to be a risk factor for increased length of stay and need for hardware removal.[38]

With regard to intraoperative findings, there were no differences between the two groups. Though 14 (50%) patients in the MMA group had arch bars placed intraoperatively, total operative time was not increased in this group. Over the timeframe of the study, the use of skeletal fixation screws became more common in lieu of arch bars, likely negating any difference in length of operation.

Postoperatively, the study group was found to have a significantly longer length of stay (LOS) than the control group (2.4 ± 0.8 vs. 1.9 ± 0.8 days, $p<0.02$). Additionally, LOS was found to have a positive correlation with increasing ASA status. The LOS of the OSA cohort in this study is similar to previously published data[9-11]. Planned admission to an intensive care unit is the current standard of care for postoperative management of OSA patients within the Department of Oral and Maxillofacial Surgery at MGH. This may also contribute the longer length of stay found in the study group.

Of the postoperative management variables studied, the only significant difference found was a greater number of analgesic prescriptions provided to the OSA group than the DFD group. The number of planned and unplanned visits and patient communications were not statistically different between the two groups.

For postoperative complications, the data were collected for 3 periods of time (acute, subacute and late). For analysis of the data, the acute and subacute timeframes were grouped as early and then compared to the late timeframe. The total number of each complication listed in Table 4 may be greater than the total number of patients experiencing said complication because some patients had the same complication more than once or during both the early and late timeframes. For example, wound dehiscence occurred more than once

in a single patient resulting in 5 patients experiencing 6 wound dehiscences. One patient had dysesthesia lasting beyond the early timeframe resulting in 6 patients with 7 total dysesthesias. Of the complications occurring statistically more frequently in the OSA group, velopharyngeal insufficiency was noted to have occurred only during the early timeframe and to have completely resolved by the late timeframe. Conversely, reoperation occurred more often during the late timeframe. It appears that the majority of the reoperations were related to removal of hardware due to infection and not loss of fixation.

Some of the postoperative complications were only evaluated during the late timeframe as they could not be adequately evaluated during the early period. For example, it is expected that most patients will have at least transient lower lip and chin paresthesia during the postoperative period, so detailed neurosensory testing was not completed until the late timeframe in many patients. Similarly, final esthetics and TMJ pain and function following surgical interventions cannot be accurately assessed in the early postoperative timeframe. Interestingly, it was found that TMJ pain was statistically more frequent in the DFD group than the OSA group. One of the two possible explanations for this is that TMJ pain was more prevalent preoperatively in the DFD group. The second possibility is that the postoperative TMJ discomfort in the DFD group may be related to the planned change in occlusion. The occlusion was only rarely changed in the OSA group.

Postoperative complications were overwhelmingly minor in nature, requiring no readmission or reoperation under general anesthesia. Of the 108 complications in the OSA group, 15 (13.9%) fell into the major category while 1 (3.0%) of the DFD group's 33 total complications were major. Infection was the cause of all major complications. There were a total of 25 infections in the OSA group, 12 of which were major (48%) while there were a total of 6 infections in the DFD group, 1 of which was major (16.7%). It appears that infections occur more frequently in OSA patients and when they occur, are more likely to require readmission or reoperation under general anesthesia than in DFD patients.

At the late timeframe, there was no difference in the number of patients experiencing paresthesia but there was a significantly greater number of patients in the OSA group having dysesthesia. This may perhaps be due to the amount of advancement completed in the OSA group, which is presumed to be greater than the DFD group. Additionally, the greater mean age of the OSA cohort (41.9 years) compared to the DFD cohort (21.7 years) likely plays a role in the neurosensory changes seen. Similar to other previously published studies[11,39], a patient reported complaint of an unesthetic facial appearance at the late timeframe was rare and there was no difference seen between the two groups. This is reassuring considering that the amount of advancement completed during MMA for treatment of OSA tends to be large and can be beyond cephalometric norms.

Correlations between the demographic, disease related, intra and post-operative variables and complications that were moderate to strong and that were statistically significant to a $p<0.01$ were considered clinically important. As expected, there was a strong correlation between age, gender, BMI, ASA status, number of prescribed medications and OSA. There was a positive correlation between increasing ASA status and infections. This is not unexpected as there were more infections in the study group and the diagnosis being treated

by MMA (OSA), places a patient in a higher ASA status while the diagnosis being treated by orthognathic surgery (malocclusion) does not usually result in a change in ASA status. The strongest correlation was between reoperation and hardware removal. These were also correlated to infection. This is not surprising in that infections often lead to a need for hardware removal that is frequently completed under general anesthesia.

Patients who are smokers or have a history of smoking should be advised of the higher risk of complications. The surgeon should be aware that unplanned communications from the OSA patient does correlate with postoperative infection. Additionally, it is important to note that length of stay was highly correlated and statistically very significant with ASA status but was only weakly correlated with age and moderately correlated with OSA. This should be taken into account when counseling both OSA and DFD patients about expected length of stay following their operation.

The results of this study indicate that there were a greater number of major complications in the OSA group than in the controls and that the most common complication encountered was infection. While some of these infections ultimately required readmission and/or reoperation under general anesthesia, there were no long-term adverse surgical sequelae and none of the infections were life-threatening. There was no difference in mortality between the two groups, with no deaths occurring in either group.

We are conducting additional investigations into outcomes,and ,methods to improve patient selection for MMA to reduce complications and to better predict patient response to the operation. For example, the necessity of a postoperative ICU admission,, the current standard at our institution, is being evaluated in an attempt to identify variables which may be addressed to safely eliminate this and reduce LOS. Our group is also evaluating pre- and postoperative clinical and cephalometric skeletal and soft tissue measurements to predict outcomes and to determine the magnitude of deviation from established norms. This will allow the surgeon to provide patients more accurate preoperative counseling.

Acknowledgement

The corresponding author wishes to acknowledge Dr. Scott Boyd, Research Professor, Department of Oral and Maxillofacial Surgery and Department of Neurology, Vanderbilt University School of Medicine, for his insightful suggestions regarding this work.

This work was conducted with support from:

Harvard Catalyst | The Harvard Clinical and Translational Science Center (National Center for Research Resources and the National Center for Advancing Translational Sciences, National Institutes of Health Award UL1 TR001102) and financial contributions from Harvard University and its affiliated academic healthcare centers. The content is solely the responsibility of the authors and does not necessarily represent the official views of Harvard Catalyst, Harvard University and its affiliated academic healthcare centers, or the National Institutes of Health.

Massachusetts General Hospital Department of Oral and Maxillofacial Surgery Education and Research Fund.

Brazilian National Council for Scientific and Technological Development (CNPq), and Coordination for the Improvement of Higher Education Personnel (CAPES).

Appendix 1: Study variables

A. Preoperative

1. Age.

2. Gender.

3. BMI (weight/height^2 - kg/m^2).

4. Previous orthodontic treatment unrelated to operation.

5. Number of chronic medical comorbidities (defined as a medical problem requiring treatment via monitoring, diet/lifestyle modification, and/or medication).

6. History of cancer.

7. ASA Class (as defined by the American Society of Anesthesiologists and listed in anesthesia record).

8. Number of regular medications (defined as a medication prescribed by a physician and taken regularly to treat a medical condition).

9. Number of previous surgical procedures requiring general anesthesia.

10. Current smoker.

11. Smoking history (defined in pack years (packs per day x number of years smoking).

12. Number of alcoholic drinks/week (drink is 1oz liquor/5oz wine/8oz beer; if <1 drink/month, then will be recorded as “none”; a report of “social use” will be recorded as indeterminate).

13. Active illicit drug use (inhaled, ingested or injected illegal drugs).

B. Intraoperative

14. Fiberoptic intubation use.

15. Intubation time (defined as time from induction -identified by use of induction medications-propofol and paralytic agent- to successful intubation per anesthesia records).

16. Difficult airway (as defined by anesthesia records).

17. Use of invasive monitoring (as such ‘A line’).

18. Intraoperative use of pressors.

19. Length of operation (defined as time from start of operation -either incision or start of IMF- until patient leaves operating room).

20. Intraoperative blood loss (per operative report).

21. Use of hypotensive anesthesia: 1) hypotensive anesthesia noted in anesthesia report, 2) ”hypotension” written in the anesthesia or surgical notes, 3) systemic blood pressure (SBP) <100 mm Hg or mean arterial pressure (MAP) <70 mm Hg for >50% of the duration of the operation).

22. Perioperative steroid (steroids used either preoperatively, intraoperatively or postoperatively).

23. Preoperative antibiotics (prophylactic antibiotics given prior to or at the start of the procedure).

24. Type of IMF.

25. Intraoperative fluid rate (total crystalloid given during surgical procedure divided by procedure length).

26. Intraoperative urinary output (total urine output during surgical procedure divided by procedure length).

27. Intraoperative use of colloids.

C. Postoperative

28. Postoperative antibiotics (prophylactic antibiotics continued beyond the end of surgery while in house).

28. Antibiotic prescription given at discharge.

29. Length of stay (the interval in days between discharge from the operating room recorded on the nurse’s operating room note and the time at which discharge orders were signed).

30. Interactions following discharge divided into immediate (discharge to 2 weeks postoperative), acute (2 weeks to 3 months postoperative) and late (3 to 6 months postoperative).

a. Number of planned postoperative visits.

A planned visit is a regular scheduled visit beginning with the first scheduled postoperative visit noted in the discharge paperwork or the first documented outpatient postoperative visit (unless the documentation for that visit states the visit was unscheduled, emergent, urgent, or in response to a call to the office out of concern of a postoperative issue; in which case the visit would count as an unplanned postoperative visit) and all follow up visits that are in keeping with the details in the “Plan” section of the previous visits note.

b. Number of postoperative non-visit communications

A non-visit communication is defined as any documented interaction with a patient following surgery either in response

to a phone call or page that does not result in a clinical evaluation.

c. Number of unplanned postoperative visits.

An unplanned visit is a visit not scheduled at time of discharge or at end of a previous postoperative visit and/or a visit in which it is documented that the visit was unscheduled, emergent, urgent, or in response to a call to the office out of concern of a postoperative issue. Any documented unplanned visit to another clinic/department of the Massachusetts General Hospital or any outside medical facility regarding a postoperative issue will also be regarded as an unplanned postoperative visit.

31. Amount of pain medication prescribed postoperatively (defined as number of narcotic/scheduled pain pills patient is prescribed at time of discharge and at all subsequent postoperative visits).

32. Method for IMF (IMF screws or Arch bars) if inadequate or no orthodontic hardware already in place.

Appendix 2: Complications

1. Intraoperative

a. Number of intubation attempts (as noted in anesthesia record).

b. Need for emergent airway (per anesthesia record or operative note).

c. Need to redo fixation.

d. Witnessed trigeminal nerve injury.

e. Hemorrhage (defined as uncontrolled/poorly controlled bleeding necessitating blood products and separate, unplanned surgical or interventional radiology procedure).

f. Need for blood product administration.

g. Number of medical events (defined a new metabolic or physiologic event requiring intervention and/or intra or postoperative consultation of a different medical service as documented in the anesthesia record, nursing record or operative note. Examples include cardiovascular-dysrhythmia, hypertension; respiratory-pneumothorax, bronchiole constriction; genitourinary-traumatic Foley insertion, oligouria).

h. Unfavorable/unplanned osteotomy.

i. Unplanned use of post-operative IMF.

j. Retained hardware (hardware intended to be removed at the end of the surgical procedure but either closed into the wound or forgotten to be removed post-operatively).

k. Dental trauma (fractured tooth, root injury, tooth avulsion).

2. Immediate postoperative (after end of surgery but prior to discharge)

a. Unplanned use of higher level of postoperative care (defined as need to transfer patient from scheduled postoperative care level to more acute care level).

b. Need to return to OR.

c. Number of medical events (defined a new metabolic or physiologic event requiring unplanned testing, intervention and/or consultation of a different medical service as documented in discharge summary. Examples include cardiovascular-dysrhythmia, hypertension; respiratory-pneumothorax, bronchiole constriction; genitourinary-traumatic Foley insertion, oligouria; gastrointestinal-bowel obstruction, diarrhea)

d. Facial nerve injury.

e. Wound dehiscence.

3. Acute postoperative (<2 weeks after discharge)

a. Readmission.

b. Emergency Department visit.

c. Reoperation (defined as need to return to main operating room for a procedure related to original operation and requiring a general anesthetic with intubation).

d. Infection (defined by the need to aspirate a collection, complete an incision and drainage, and/or prescribe antibiotics).

e. Malocclusion (defined as occlusion different than planned in orthognathic patients or different from premorbid occlusion in OSA patients).

f. Nasal septum deviation.

g. Dental injury (defined as tooth devitalization requiring endodontic treatment or extraction).

h. Wound dehiscence.

i. Number of medical events (defined as a new metabolic or physiologic event requiring unplanned testing, intervention and/or consultation of a different medical service as documented in patient chart; examples include cardiovascular-dysrhythmia, hypertension; respiratory pneumothorax,

bronchiole constriction; genitourinary-urinary retention; gastrointestinal-bowel obstruction, diarrhea). j. Epistaxis requiring intervention.

4. Sub-acute postoperative (2 weeks-3 months after discharge)

a. through j. as above.

k. Loss of fixation.

l. Hardware failure.

m. Nonunion.

n. Hardware removal.

o. Upper aerodigestive issues.

- **i.** Dysphagia.
- **ii.** Dysphonia.
- **iii.** Velopharyngeal insufficiency (defined subjectively as patient complaint of hypernasality or food regurgitation through nose).

p. Dysthesia.

5. Late postoperative (>3 months after discharge)

a. Through p. as above.

q. Unsatisfactory esthetic results (as determined by surgeon and/or patient).

r. Persistent trigeminal nerve deficit.

s. Need for head and neck pain management referral due to:

- **i.** TMJ pain.
- **ii.** Myofascial pain of muscles of mastication.

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Table 1

Preoperative characteristics.

	OSA (n=28)				DFD (n=26)				
	minimum	**maximum**	**mean**	**SD**	**minimum**	**maximum**	**mean**	**SD**	***p***
Age	19	59	41.9	12.5	15	53	21.7	8.6	**<0.001**
Gender - male : female			23:5				6:20		**<0.001**
ASA	1	3	2	0.5	1	3	1.3	0.6	**<0.001**
BMI	19.4	41.6	29.6	4.7	18.5	31.4	23.0	3.1	**<0.001**
Comorbidities	0	8	2.4	2.3	0	4	0.7	1.0	**0.001**
Regular medicines	0	9	3.1	2.2	0	5	0.8	1.2	**<0.001**
Previous Surgeries	0	6	2.0	1.6	0	3	0.7	0.8	**<0.001**

Abbreviations: OSA - Obstructive Sleep Apnea; DFD - Dentofacial Deformity; SD - standard deviation; ASA - American Society of Anesthesiologists' anesthesia risk index; BMI - body mass index; kg/m^2 - in kilograms/square meters. Age - in years. For definition of variables and complications refer to Appendices 1 and 2.

Statistically significant differences ($p \leq 0.05$) are indicated in bold.

Table 2

Intraoperative variables

	OSA (n=28)				DFD (n=26)				
	minimum	**maximum**	**mean**	**SD**	**minimum**	**maximum**	**mean**	**SD**	***p***
Time of intubation	2	17	8.8	4.1	1	18	7.1	4.9	0.195
Length of operation	6	10	7.2	1.1	5	11	6.6	1.4	0.098
Estimated blood loss	110	1000	437.0	205.8	120	935	421.2	207.3	0.783
Intraoperative fluid rate	126	886	556.8	171.7	350	1091	599.0	205.2	0.415
Intraoperative urine output	20	1000	150.7	223.4	28	390	90.6	89.4	0.206

Abbreviations: OSA - Obstructive Sleep Apnea; DFD - Dentofacial Deformity; SD = standard deviation; Units: Time of intubation - minutes; length of operation - hours; Estimated blood loss - milliliters; Intraoperative fluid rate - milliliters; Intraoperative urine output - milliliters/hour. For definition of variables and complications refer to Appendices 1 and 2.

Statistically significant differences ($p \leq 0.05$) are indicated in bold.

Table 3

Postoperative variables.

	OSA (n=28)				DFD (n=26)				
	minimum	**maximum**	**mean**	**SD**	**minimum**	**maximum**	**mean**	**SD**	***p***
Length of stay at hospital	1	4	2.4	0.8	1	4	1.9	0.8	**0.016**
Planned visits	4	15	7.4	2.7	4	13	6.5	2.3	0.180
Unplanned visits	0	8	1.1	1.6	0	2	0.5	0.9	0.097
Emergency Department visits	0	3	0.3	0.6	0	1	0.0	0.2	0.115
Unplanned communications	0	7	1.6	1.6	0	4	0.9	1.2	0.083
Number of extra analgesic prescriptions	0	3	1.0	1.0	0	1	0.2	0.4	**0.001**

Abbreviations: OSA - Obstructive Sleep Apnea; DFD - Dentofacial Deformity; SD = standard deviation. For definition of variables and complications refer to Appendices 1 and 2.

Statistically significant differences ($p \leq 0.05$) are indicated in bold.

Table 4

Number of early and late complications, and number of patients with postoperative complications.

	EARLY			LATE			TOTAL			PATIENTS		
	OSA	**DFD**	***p***	**OSA**	**DFD**	***p***	**OSA**	**DFD**	***p***	**OSA**	**DFD**	***p***
Dental injury	0	0	–	1	1	0.96	2	0	0.96	1	1	1.00
Dental malocclussion	3	1	0.35	3	1	0.35	6	2	0.16	6	2	0.25
Dysesthesia	4	0	**0.05**	3	0	0.09	7	0	**0.02**	6	0	**0.02**
Dysphagia	1	0	0.34	0	0	–	1	0	0.34	1	0	1.00
Dysphonia	1	0	0.34	0	0	–	1	0	0.34	1	0	1.00
ED Visit	6	1	0.10	1	0	0.34	7	1	0.11	5	1	0.19
Epistaxis	0	2	0.14	0	0	–	0	2	0.16	0	2	0.23
Hardware Removal	4	0	**0.05**	10	0	**0.002**	14	0	**0.001**	11	0	**<0.001**
Infection	17	3	**0.001**	8	3	0.17	25	6	**0.001**	18	6	**0.002**
Loss of fixation	0	0	–	1	0	0.34	1	0	0.34	1	0	1.00
Medical event	8	3	0.17	2	0	0.17	10	3	0.1	8	3	0.18
Myofascial pain	–	–	–	1	3	0.27	1	3	0.28	1	3	0.34
Nasal septum deviation	1	1	0.96	1	1	0.96	2	2	0.94	2	2	1.00
Non-union	0	0	–	2	0	0.17	2	0	0.16	2	0	0.49
Readmission	1	1	0.96	4	0	0.11	5	1	0.21	3	1	0.61
Reoperation	2	0	0.17	8	0	**0.003**	**10**	**0**	**0.002**	9	0	**0.002**
TMJ pain	–	–	–	0	4	**0.03**	**0**	**4**	**0.04**	0	4	**0.05**
Trigeminal Nerve deficit	–	–	–	4	7	0.26	4	7	0.26	4	7	0.32
Unesthetic result	–	–	–	0	1	0.3	0	1	0.33	0	1	0.48
VPI	5	0	**0.02**	0	0	–	5	0	**0.02**	5	0	0.05
Wound dehiscence	5	0	0.061	1	0	0.340	6	0	0.057	5	0	0.052

Abbreviations: OSA - Obstructive Sleep Apnea; DFD - Dentofacial Deformity, ED - Emergency Department; TMJ - Temporomandibular Joint; VPI - Velopharyngeal insufficiency. For definition of variables and complications refer to Appendices 1 and 2.

Statistically significant differences ($p \leq 0.05$) are indicated in bold.

Table 5

Correlations between pre and postoperative variables (n=54).

	ASA	BMI	Medication	Comorbidity	Intubation Time	Length of Stay	Infection	Hardware Removal	Loss of Fixation	Non Union
OSA	**.59**	**.68**	**.60**	.44**	.24	.34*	.44**	.49**	.13	.19
Age	**.62**	**.70**	**.75**	**.60**	.29*	.27	.40**	.42**	−.07	.05
ASA	1.00	**.54**	**.55**	**.65**	.22	**.52**	**.53**	.37**	.09	.12
Current Smoker	.01	−.15	.17	.06	.29*	.08	.14	.26	**.57**	.38**
Smoking History	.24	.07	.34*	.13	.34*	.23	.32*	.31*	.33*	.19
Unplanned Communication	.25	.07	.24	.22	.08	.13	.45**	.31*	.24	.07
Infection	**.53**	.35	.36**	.39**	.08	.23	1.00	**.59**	.23	.26
Readmission	.35*	.13	.24	.24	.18	.34*	.31*	.37**	**.51**	**.69**
Reoperation	.34*	.34*	.33*	.26	.12	.21	**.62**	**.89**	.30*	.43**

Abbreviations: OSA - Obstructive Sleep Apnea; ASA - American Society of Anesthesiologists' anesthesia risk index; BMI - body mass index (kg/m^2). For definition of variables and complications refer to Appendices 1 and 2.

** All strong correlations (R>0.5 and p<0 .01) are in bold, the moderate correlations (R>0.3 and <0.5) with p <0 .01 are marked.

* All strong correlations (R>0.5 and p<0 .01) are in bold, the moderate correlations (R>0.3 and <0.5) with p < 0.05 are marked.