Master's Thesis of Dental science

Effects of Modified Maxillo-mandibular Advancement surgery for patients with severe obstructive sleep apnea on change in quality of life and facial aesthetics

수면무호흡증 치료를 위한 변형된 양악전진술이 삶의 질 및 얼굴의 심미성 변화에 미치는 효과

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Graduate School of Dental science
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Oral and Maxillofacial Surgery Major

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Abstract

Purpose/Objective: The purpose of this study is to retrospectively evaluate and compare the postoperative effects of modified Maxillo-mandibular advancement (MMA) to that of conventional MMA on quality of life and aesthetic satisfaction of patients

Methods: Through chart review, medical records, 28 pre- and post-surgical follow-up responses regarding the change in quality of life and facial appearances who were 1. diagnosed with moderate to severe OSA and an AHI of 15 or higher, and 2. received conventional and modified MMA from January 1st, 2013, to December 31st, 2022, will be analyzed to investigate the improvement of quality of life and facial appearance after MMA surgery. The Likert scale with 1 sample Wilcoxon signed rank test will be used for patient responses on questions regarding the Quality of life and change in facial appearance where 3 means no change, 4 and 5 means improvement in QOL, and 1 and 2 meaning reduction in QOL. Wilcoxon rank sum test will be used to see the difference in responses between patients who have undergone conventional and modified MMA, which P value of less than 0.05 will mean the difference is statistically significant. Finally, 3 cases were selected for case review purposes.

Results: Out of 24 patients, all patients were skeletal Class II. 17 patients were men, and 7 patients were women. 17 patients have received modified MMA and 7 have received conventional MMA. The mean age at surgery for conventional MMA was 30.0±8.16 years with a range of 18 - 39 years. The mean age at surgery for modified MMA was 32.6±13.8 years with a range of 4 – 59 years. The mean pre-op AHI for

conventional MMA was 52.0±20.0 with a range of 28.0 – 76.6 (moderate to severe OSA). The mean pre-op AHI for conventional MMA was 52.2±21.3 with a range of 23.3 – 85.6. The mean of post operative AHI for conventional MMA was 10.4±8.10. The mean of post operative AHI for modified MMA was 8.89±4.66. The average length of advancement of the maxilla for patients who have undergone conventional MMA was 5.00±1.89mm from incisal edge position. The average length of advancement of the maxilla for patients who have undergone modified MMA was 2.39±1.42mm from incisal edge. The average length of advancement after BRSSO of the right side for conventional MMA was 7.05±2.05mm and 8.90±2.30 for modified MMA. The left side for conventional MMA was 6.65±2.05mm and 8.27±2.50 for modified MMA (from mesio-buccal cusp of first molar).

Patients that received conventional MMA responded positively that their Sleep Quality, Daytime function, Physical health, Mental health, Dental function, Recovery, Facial appearance has improved ($P<0.05$). Patients that received modified MMA responded positively that their Sleep quality, Daytime function, Physical health, Dental function has improved ($P<0.05$). Although statistically insignificant, modified MMA patients have also said their facial appearance has improved ($P=0.446$). However, they reported their speech quality has reduced. ($P=0.124$)

An analysis of the difference in change of quality of life and facial appearances between conventional and modified MMA has shown that the results were statistically significant in the following categories: “Increased ease of daytime breathing”, “better overall health”, “greater energy”, “better overall mood”, “better in speech quality” ($P<0.05$). In the facial aesthetics category, the difference between the two surgeries showed that they were statistically insignificant: “Did not like

appearance of lower jaw before surgery" (P=0.258), "Did not like appearance of upper jaw before surgery" (P=0.067), "Was not confident of looks before surgery" (P=0.508), "Happy with how my lower jaw has changed" (P=0.599), "Happy with how my upper jaw has changed" (P=0.692), "Gained confidence of the way I look" (P=0.338), "Like the overall change of the way I look" (P=0.915).

Conclusion: Conventional and modified MMA surgery has been shown to enhance the quality of life and improve or at least preserve facial aesthetics. Modified MMA offers the advantages of maximizing posterior airway space while reducing the degree of maxillomandibular complex advancement, thus minimizing the protrusive facial appearance that may be aesthetically undesirable for the patient. Consequently, Modified MMA not only improves postoperative quality of life but also increases satisfaction with facial appearance.

Keywords: OSA, MMA, modified MMA, Quality of life, Facial appearance, Esthetics

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Introduction

Obstructive sleep apnea (OSA) is a sleep disorder characterized by recurrent episodes of partial or complete blockage of the upper airway during sleep, leading to interruptions in breathing. OSA is a serious medical condition which can cause significant decrease in quality of life of patients and can even lead to death.[1] Because OSA is caused by the obstruction of the airway, OSA symptoms can be improved by increasing the posterior airway space, which will allow patients to breathe better in their sleep.[1,2] It is a common chronic disease that can cause hypoxemia, sleep fragmentation, hypertension, cardiac arrhythmias, stroke, diabetes, decreased work performance, decreased quality of life (QoL), and increased mortality.[1,3] Among OSA patients, patients especially with moderate to severe OSA of Apnea-Hypopnea Index (AHI) 15 to 30 or more experience symptoms that can be intolerable in one's daily life.

Today, there are surgical and non-surgical methods to treat OSA. Continuous positive airway pressure (CPAP), a non-surgical method, is one of the most widely used method that keeps the airway open, allowing for continuous airflow and reducing the frequency and severity of apnea episodes.[4] CPAP therapy can improve the quality of sleep, reduce daytime sleepiness, and improve overall well-being.[1,5,6] CPAP is better in reducing AHI, in improving quality of life, in decreasing blood pressure than Oral appliances.[6] CPAP has also proven to show that it reduces major adverse cardiovascular events (MACE) such as stroke and other cardiovascular diseases.[6] When using the CPAP machine, the patient will need to wear a mask and headgear that is connected to the machine through a tube. The mask is customizable

to fit the individual needs of each patient. However, side effects such as nasal congestion, dry mouth, skin irritation from using the mask can be uncomfortable for the patient. The CPAP machine is an expensive equipment and patients who travel will have a hard time bringing the machine with them, which in turn causes problems such as compliance.[7] Prolonged use of this device will also cause patients to become dependent on CPAP therapy to achieve a good night's sleep.

Oral appliance is also a simple solution that does not require surgery. Oral appliances are worn like orthodontic retainers. It works by pushing or pulling the lower jaw forward, thereby creating more airway space. Oral appliances are easy to use, small, portable, ideal for travel; however, it is used for patients with mild to moderate OSA.[6] Patients with more severe OSA are less likely to benefit from Oral appliances. When Oral appliances are not an effective treatment of choice, CPAP should be considered. [6]

Among surgical methods, Uvulopalatopharyngoplasty (UPPP) is a more permanent solution that does not require additional appliances like CPAP and Oral appliances. UPPP is an effective treatment that increases the posterior airway space by removing excess tissue such as the soft palate, uvula, and pharynx from the throat. Like other treatment options, UPPP also reduces snoring, improves sleep quality, reduces health complications such as high blood pressure, heart disease, and stroke.[8] However, like any surgical procedure, UPPP carries risks such as bleeding, infection, post-operative pain, possible need for additional surgery, and moreover, difficulty swallowing, nasal regurgitation, and even voice changes. [8] Also, UPPP is most often limited for patients with mild to moderate OSA. [8] When non-surgical methods such as CPAP and OA, along with surgical methods such as the UPPP surgery are not

effective or not an option for treating patients, Maxillo-mandibular advancement (MMA) can be considered.

MMA is a surgery which involves both the maxilla and mandible. It entails advancing the maxilla through Le Fort 1 osteotomy and mandible through Bilateral sagittal split ramus osteotomy (BSSRO). By advancing and rotating the maxillomandibular complex counterclockwise, the posterior airway space is increased, thereby dramatically reducing symptoms of OSA. Several studies have demonstrated that MMA surgery is an effective treatment of choice for patients with moderate to severe OSA.[1,2,3,9,10,11] MMA has gained its reputation as an effective treatment of choice for patients with moderate to severe obstructive apnea. Previous studies have been conducted to demonstrate the efficacy of MMAs in treating patients with OSA and to access patient satisfaction following the procedure.[2,9] Also, studies have been conducted to prove the efficacy of different types of MMA surgery in QoL and facial appearances.

However, in South Korea, there is a lack of studies investigating the subjective aspect of how patients perceive their QoL and change in facial appearances after the surgery. Especially, as it is called Maxillo-mandibular "advancement", when considering surgery, it is crucial for the surgeon to consider the extent to which the maxilla and mandible will protrude after the procedure, as it can significantly impact facial appearance. Changes in facial appearance tend to influence patient's QoL and subjective satisfaction with the surgery. [4,12,13]

The modified MMA differs from the conventional method in that, in addition to Le Fort I osteotomy or BSSRO, additional Anterior segmental osteotomy (ASO) is performed. Furthermore, modified MMA uses the space created by extracting the

first premolars to generate additional space for advancing the posterior segment of the maxilla, thereby creating more airway space and avoiding excessive advancement of the maxilla, which could result in a protruded mouth. Particularly in Asian countries, a protruded mouth is often considered esthetically undesirable.[4] Therefore, Asians are more likely to benefit esthetically from the modified MMA surgery than the conventional method.

In this study, we will investigate the patients' satisfaction with esthetic changes after conventional MMA and modified MMA and the differences in the effects that conventional MMA and modified MMA have on QoL and facial appearances. Although personal satisfaction with one's facial appearance is subjective, enhancements in facial esthetics can enhance one's confidence, which may also impact the patient's QoL. This retrospective study aims to access patient's satisfaction after MMA surgery and investigate how modified MMA differs from conventional MMA in its effects on QoL and facial appearance.

Null Hypothesis: There is no difference between conventional MMA and modified MMA in their effects on change in quality of life and facial aesthetics for patients with severe obstructive sleep apnea.

Materials and methods

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After chart review, the medical records of patients diagnosed with moderate to severe OSA and an Apnea-Hypopnea Index (AHI) of 15 or higher, who underwent MMA surgery between January 1st, 2013, to December 31st, 2022, will be collected. Additionally, responses to 28 questions pertaining to QoL and facial appearance obtained after 3 months and up to 1 year after the operation were collected. These records and questionnaire data will be recorded and analyzed to investigate the improvement in quality of life and facial appearance following the surgery.

Inclusion criteria

Patients who received MMA surgery from 2013 to 2022 at the Seoul National University Dental Hospital (SNUDH). Patients with diagnosed moderate to severe OSA with an AHI of 15 or more using Nocturnal polysomnography. Patients who have actively come back for follow-up and have answered pre- and post-operative questions regarding QoL and changes in facial appearance will be included in the study

Exclusion criteria

Diagnosed OSA with an AHI of 15 or less using Nocturnal polysomnography. Patients who did not receive MMA will be excluded.

Surgery

After 3D virtual surgical planning and cephalometric radiograph analysis, a standard Le Fort I osteotomy and BSSRO with rigid internal fixation was done on 7 patients and a Le Fort I osteotomy with ASO, which is maxillary anterior subapical osteotomy, BSSRO with ASO, which is mandibular anterior segmental subapical osteotomy, and surgical extraction of the 1st premolars (#14, 24, 34, 44) before receiving ASO was done on 17 patients. Genioglossus advancement was done on some patients who needed esthetic adjustment. Patients received maxillomandibular fixation after surgery.

Data Collection

28 questions (Table 1) on change in QoL and facial appearances were asked during patient's follow-up were recorded. Along with 21 questions pertaining to changes after surgery and changes of the QoL (sleep quality, daytime function, mental health, recovery, dental function), 7 Questions related to the change in esthetic appearance were asked.

The 21 questions pertaining to QoL after surgery is as follows:

1. Decreased use of sleeping pills
2. Reduced frequency of waking up to urinate
3. Reduced frequency of night walking
4. Reduced frequency of snoring
5. Improved sleep quality
6. Reduced Obstructive sleep apnea
7. Improved concentration
8. Improved ability to stay awake
9. Increased ease of daytime breathing
10. Better overall health
11. Greater energy
12. Improved relationships
13. Better mood

14. Reduced stress over sleep arrangements
15. Better in speech quality
16. Better swallowing ability
17. Less headaches
18. Pain after surgery
19. Occlusion after surgery
20. TMJ after surgery
21. Improved teeth alignment

The 7 questions pertaining to change in facial appearances after surgery is as follows:

1. Did not like appearance of lower jaw before surgery
2. Did not like appearance of upper jaw before surgery
3. Was not confident of looks before surgery
4. Happy with how my lower jaw has changed
5. Happy with how my upper jaw has changed
6. Gained confidence of the way I look
7. Like the overall change of the way I look

Demographics and medical records

Through chart review, Age at surgery, AHI, BMI, method of surgery, maxillary anterior segment advancement length from incisal edge position, maxillary posterior segment advancement length from the mesio-buccal cusp of 1st molars. BSSRO advancement length for left and right each from the mesio-buccal cusp of 1st molars, and Maxillomandibular fixation duration were collected (Table 2).

Statistical analysis methods

Excel version 16.60 (Microsoft) and the statistical computing program R was used. Unpaired T-test was used to find statistically significant differences between conventional MMA and modified MMA in demographical data. Using the T-test, Standard error and P value were calculated for demographic data to measure the

accuracy with which the sample distribution represents the population. In 5-point Likert scale, strongly disagree was given the score 1, disagree 2, neither agree/disagree 3, agree 4, and strongly agree 5. 3 means no change, 4 and 5 means improvement in QoL and facial appearance, and 1 and 2 meaning reduction in QoL and facial appearance. The data were analyzed using 1-sample Wilcoxon signed rank test (mu=3) with responses from patients who have undergone Conventional MMA, responses from patients who have undergone Modified MMA, and finally using Wilcoxon rank sum test to compare conventional MMA (control group) and modified MMA (experimental group) whether their differences in responses were significant.

Results

Statistical Analysis

Demographics (Table 2)

All patients were skeletal class II. All patients who have received modified MMA surgery received extraction of 1st premolars and pre-orthodontic treatment prior to surgery. Out of 24 patients, 17 patients were men, and 7 patients were women. 17 patients have received modified MMA and 7 have received conventional MMA. All patients were skeletal Class II. The mean age at surgery for conventional MMA was 30.0±8.16 years with a range of 18 - 39 years. The mean age at surgery for modified MMA was 32.6±13.8 years with a range of 4 – 59 years. The mean pre-op AHI for conventional MMA was 52.0±20.0 with a range of 28.0 – 76.6 (moderate to severe OSA). The mean pre-op AHI for conventional MMA was 52.2±21.3 with a range of 23.3 – 85.6. The mean of post operative AHI for conventional MMA was 10.4±8.10. The mean of post operative AHI for modified MMA was 8.89±4.66. The average length of advancement of the maxilla for patients who have undergone conventional MMA was 5.00±1.89mm from incisal edge position. The average length of advancement of the maxilla for patients who have undergone modified MMA was 2.39±1.42mm from incisal edge. The average length of advancement after BRSSO of the right side for conventional MMA was 7.05±2.05mm and 8.90±2.30 for modified MMA. The left side for conventional MMA was 6.65±2.05mm and 8.27±2.50 for modified MMA (from mesio-buccal cusp of first molar). Unpaired T-test was used to find statistically significant differences between conventional MMA and modified

MMA in demographical data, and the only difference of "average length of advancement of the maxilla from incisal edge" was statistically significant ($P<0.05$).

Responses from conventional MMA patients vs. modified MMA patients regarding quality of life
(Table 3, figures 1 and 2)

For conventional MMA, the results in the Sleep quality category were the following: Decreased use of sleeping pills (Mean, 4.43; $P<0.05$), Reduced frequency of waking up to urinate (Mean, 4.14; $P<0.05$), Reduced frequency of night walking (Mean, 4.43; $P<0.05$), Reduced frequency of snoring (Mean, 4.43; $P<0.05$), Improved sleep quality (Mean, 4.57; $P<0.05$), Reduced obstructive sleep apnea (Mean, 4.57; $P<0.05$). The results in the Daytime function category were the following: Improved concentration (Mean, 4.00; $P<0.05$), Improved ability to stay awake (Mean, 4.00; $P<0.05$). The results in the Physical health category were the following: Increased ease of daytime breathing (Mean, 4.57; $P<0.05$), Better overall health (Mean, 4.57; $P<0.05$), Greater energy (Mean, 4.57; $P<0.05$). The results in the Mental Health category were the following: Improved relationships (Mean, 4.14; $P<0.05$), Better overall mood (Mean, 4.57; $P<0.05$), Reduced stress over sleep arrangements (Mean, 4.57; $P<0.05$). The results in the Recovery Category were the following: Better speech quality (Mean, 3.71; $P<0.05$), Better swallowing ability (Mean, 3.86; $P<0.05$), Less headaches (Mean, 3.71; $P<0.05$), Pain after surgery (Mean, 2.86; $P < 0.05$). The results in the Dental function category were the following: Better occlusion after surgery (Mean, 3.43; $P < 0.05$), Better TMJ sensation after surgery (Mean, 3.86; $P < 0.05$), Improved teeth alignment (Mean, 3.43; $P < 0.05$)

For modified MMA, the results in the Sleep quality category were the following: Decreased use of sleeping pills (Mean, 3.69; P<0.05), Reduced frequency of waking up to urinate (Mean, 3.56; P<0.05), Reduced frequency of night walking (Mean, 3.81; P<0.05), Reduced frequency of snoring (Mean, 4.25; P<0.05), Improved sleep quality (Mean, 4.44; P<0.001), Reduced obstructive sleep apnea (Mean, 4.19; P<0.05). The results in the Daytime function category were the following: Improved concentration (Mean, 3.50; P<0.05), Improved ability to stay awake (Mean, 3.69; P<0.05). The results in the Physical health category were the following: Increased ease of daytime breathing (Mean, 3.88; P<0.05), Better overall health (Mean, 3.56; P<0.05), Greater energy (Mean, 3.63; P<0.05). The results in the Mental Health category were the following: Improved relationships (Mean, 4.14; P=0.174), Better overall mood (Mean, 3.75; P<0.05), Reduced stress over sleep arrangements (Mean, 3.94; P<0.05). The results in the Recovery Category were the following: Better speech quality (Mean, 2.63; P=0.124), Better swallowing ability (Mean, 3.86; P=0.160), Less headaches (Mean, 3.69; P<0.05), Pain after surgery (Mean, 2.86; P=0.276). The results in the Dental function category were the following: Better occlusion after surgery (Mean, 3.56; $P < 0.05$), Better TMJ sensation after surgery (Mean, 3.75; $P < 0.05$), Improved teeth alignment (Mean, 4.00; $P < 0.05$)

After Wilcoxon rank sum test, the difference between conventional MMA and modified MMA was statistically significant in the following categories: Increased ease of daytime breathing ($P < 0.05$), better overall health ($P < 0.05$), greater energy ($P < 0.05$), improved relationships ($P < 0.05$), better overall mood (P

< 0.05), better in speech quality ($P < 0.05$). It was not statistically significant for other categories (Table 3).

Responses from conventional MMA patients vs. modified MMA patients regarding change in facial appearance
(Table 4, figures 1 and 2)

The results in the Facial appearance category for conventional MMA were the following: Did not like appearance of lower jaw before surgery (Mean, 3.57; P=0.279), Did not like appearance of upper jaw before surgery (Mean, 2.71; P=0.424), Was not confident of looks before surgery (Mean, 3.00; P<0.05), Happy with how my lower jaw has changed (Mean, 4.00; P<0.05), Happy with how my upper jaw has changed (Mean, 3.57; P<0.05), Gained confidence of the way I look (Mean, 3.86; P<0.05), Happy with the overall change of the way I look (Mean, 3.86; P<0.05).

The results in the Facial appearance category for modified MMA were the following: Did not like appearance of lower jaw before surgery (Mean, 4.19; P<0.05), Did not like appearance of upper jaw before surgery (Mean, 3.30; P=0.156), Was not confident of looks before surgery (Mean, 3.25; P=0.390), Happy with how my lower jaw has changed (Mean, 3.56; P=0.150), Happy with how my upper jaw has changed (Mean, 3.56; P=0.135), Gained confidence of the way I look (Mean, 3.25; P=0.615), Happy with the overall change of the way I look (Mean, 3.63; P=0.116).

After Wilcoxon rank sum test, the difference between conventional MMA and modified MMA in facial appearance was not statistically significant in all categories (Table 3): Did not like appearance of lower jaw before surgery (P=0.258), Did not like appearance of upper jaw before surgery (P=0.07), Was not confident of looks before surgery (P=0.508), Happy with how my lower jaw has changed

(P=0.599), Happy with how my upper jaw has changed (P=0.692), Gained confidence of the way I look (P=0.338), Happy with the overall change of the way I look (P=0.116).

The following 3 cases were presented to better understand the results of this study.

Case Review

Case 1. Conventional MMA and Genioglossus advancement (Figure 4)

Case 1 is a patient who received conventional MMA surgery. The patient's chief complaint was "My lower jaw is too small, and I have OSA. I feel tired all the time even with a good night's sleep". After treatment planning, it was decided that the patient did not need a significant amount of advancement. The patient's nasolabial angle was obtuse, thus allowing for vertical impaction of the maxilla for counterclockwise rotation of the maxillomandibular complex. After vertical impaction, the maxilla was advanced 2mm from incisal position and the nasolabial angle decreased. The patient's left and right side of the mandibular was advanced 4.8mm and 8.5mm accordingly. The patient was satisfied with the aesthetic result and quality of life. The patient's AHI reduced from 28.2 to 10.0. The patient also received Genioglossus advancement, which not only helped his OSA symptoms reduce but also further protrude the chin to give him a balanced Skeletal Class I facial appearance.

Case 2. Modified MMA and Genioglossus advancement (Figure 5)

Case 2 is a patient that has undergone modified MMA surgery. The patient's chief complaint was that "I want to get rid of my OSA symptoms and my mouth is

too protruded". Due to labioversion of the anterior incisors and acute nasolabial angle, the patient could not advance the maxilla too much. In order to minimize protrusion, extraction of 1st premolars was done to maximize advancement of the posterior segment of the maxilla thus minimizing protrusion due to the advancement of the anterior segment and maximizing posterior airway space. No vertical impaction was done. The anterior segment of the maxilla was advanced 3mm from the incisal edge and 6mm from the mesio-buccal cusp of 1st molars, and 8.8 mm (left) and 11.7mm (right) of the mandible. This patient's AHI has decreased from 85.6 to 13.8. The patient was satisfied with the change in quality of life and facial appearance. Additional genioglossus advancement assisted in increasing posterior airway space minimizing the class II look.

Case 3. Conventional MMA and Genioglossus advancement (Figure 6) (Orthodontic treatment including extraction of premolars prior to considering MMA to treat OSA)

Case 3 is a patient who told "my nose is too flat" before surgery. Pre-operatively, the patient's lower lip to E plane was positive. Because the patient already had the premolars extracted during orthodontic treatment prior to surgery, conventional MMA surgery was the only option, thus not being able to use extracted premolar space to minimize protrusion of the mouth and making the protrusion more prominent because of the flat and short nose. The distance from the nose tip to the labial region would be technically shorter if advancement is significant. Vertical impaction of 2mm was done and maxilla was advanced 2mm from incisal edge, and 8.3mm (left) and 7.6mm (right) of the mandible. In this case, it would have been beneficial for the patient if orthodontist was able to understand the potential need of MMA surgery for Skeletal/dental Class II patients due to OSA prior to starting

orthodontic treatment. If orthodontist recognized the necessity of MMA due to OSA, it would have been possible to use the premolar space and use it later to minimize the amount of advancement needed in the future. However, the patient was still satisfied, and AHI was reduced from 39.3 to 1.3. The lower lip to E plane has become negative and the additional genioglossus advancement has improved esthetics of the mandible and overall facial appearance.

Discussion

When OSA is severe, non-surgical methods alone often prove insufficient in relieving symptoms that can greatly disrupt daily life. In previous studies, MMA has demonstrated its effectiveness in addressing the negative impacts associated with obstructive sleep apnea, ultimately leading to an improved quality of life for patients.[1,2,3,9,14]

In South Korea, there is a lack of studies investigating the subjective aspect of how patients perceive their quality of life and facial appearance after MMA surgery. Specifically, our study differs from other studies in that we have examined both conventional (control) and modified (experimental) MMA on their effects on quality of life and facial appearance and have tested for differences in the satisfaction level between the two surgeries.

In our study, patients who underwent MMA surgery, both conventional and modified MMA, reported significant improvements in their overall quality of life and facial appearances. For conventional MMA, patients noted a reduction in the use of sleeping pills (Mean 4.43, $P<0.05$), decreased frequency of waking up to urinate (Mean 4.14, $P<0.05$), fewer instances of sleepwalking (Mean 4.43, $P<0.05$), decreased snoring frequency (Mean 4.43, $P<0.05$), improved sleep quality (Mean 4.57, $P<0.05$), and a decrease in observed apnea episodes (Mean 4.57, $P<0.05$). Patients reported improved concentration (Mean 4.00, $P<0.05$) and enhanced ability to stay awake (Mean 4.00, $P<0.05$), indicating a significant enhancement in their daytime functioning post-surgery. Patients also reported experiencing easier daytime breathing (Mean 4.57, $P<0.05$), improved overall health (Mean 4.57, $P<0.05$), and

increased energy levels after the surgery (Mean 4.57, P<0.05), indicating a substantial improvement in their physical well-being. Furthermore, patients indicated improvements in interpersonal relationships (Mean 4.14, P<0.05), overall mood (Mean 4.57, P<0.05), and reduced stress related to sleep arrangements (Mean 4.57, P<0.05), highlighting their improved socio-psychological well-being. Regarding speech quality, patients reported improvement (Mean 3.71, P<0.001). Patients also reported increased swallowing ability (Mean 3.96, P<0.05) and decrease in headache frequency (Mean 3.71, P<0.05). Patients were closer to neutral with pain tolerability (Mean 2.86, P=0.073) and exhibited improved occlusion (Mean 3.52, P=0.345) but both were but was statistically insignificant. Patients reported positive changes in temporomandibular joint (TMJ) functioning (Mean 3.86, P<0.05). This could be attributed to the achievement of a Class I skeletal and occlusion relationship following the surgery. Additionally, patients experienced improved teeth alignment (Mean 3.43, P=0.233), due to pre- and post-surgery orthodontic treatment; however, this was statistically insignificant.

Finally, patients who have received conventional MMA reported dissatisfaction with the appearance of their lower (Mean 3.57, P=0.279) and upper jaw (Mean 2.71, P=0.424) before surgery and expressed satisfaction with the subsequent changes in their facial appearance: Upper Jaw (Mean 3.57, P<0.05) and Lower Jaw (Mean 4.00, P<0.05). They expressed happiness with the overall transformation (Mean 3.86, P<0.05). Our study's findings align with those of Butterfield et al., Cillo et al. and Li et al.[2,9,13] Patients also responded that they experienced “increase in their confidence” (Mean 3.86, P<0.05).

For modified MMA, patients noted a reduction in the use of sleeping pills (Mean 3.69, $P<0.05$), decreased frequency of waking up to urinate (Mean 3.56, $P<0.05$), fewer instances of sleepwalking (Mean 3.81, $P<0.05$), decreased snoring frequency (Mean 4.25, $P<0.05$), improved sleep quality (Mean 4.44, $P<0.001$), and a decrease in observed apnea episodes (Mean 4.19, $P<0.05$). Patients reported improved concentration (Mean 3.50, $P<0.05$) and enhanced ability to stay awake (Mean 3.69, $P<0.05$), indicating a significant enhancement in their daytime functioning post-surgery. Patients also reported experiencing easier daytime breathing (Mean 3.88, $P<0.05$), improved overall health (Mean 3.56, $P<0.05$), and increased energy levels after the surgery (Mean 3.63, $P<0.05$), indicating a substantial improvement in their physical well-being. Furthermore, patients indicated that their interpersonal relationships were closer to neutral (Mean 3.25, $P=0.174$). This is a contrast to responses of conventional MMA, which patients reported significant improvement in interpersonal relationships. This is because facial changes in conventional MMA is much more dramatic than modified MMA, which the surgeon attempts to minimize protrusion and results in a change less dramatic than conventional MMA. Patients reported improvement in overall mood (Mean 3.75, $P<0.05$), and reduced stress related to sleep arrangements (Mean 3.94, $P<0.05$), highlighting their improved socio-psychological well-being. Regarding speech quality (Mean 2.63, $P=0.124$) and swallowing ability (Mean 3.38, $P=0.160$), patients expressed a neutral stance; however, the responses were statistically insignificant. This can be because the time when the question was asked was not too distant, 3 months and no later than 1 year from post-surgery. However, they reported decrease in headache frequency (Mean 3.69, $P<0.05$). Patients were closer to neutral with pain

tolerability (Mean 3.31, P-0.276) and exhibited improved occlusion (Mean 3.56, P<0.001), along with positive changes in temporomandibular joint (TMJ) functioning (Mean 3.75, P<0.05). Similar to the reason of responses from that of conventional MMA, this could be attributed to the achievement of a Class I skeletal and occlusion relationship following the surgery. Additionally, patients experienced improved teeth alignment (Mean 3.83, P<0.001), due to pre- and post-surgery orthodontic treatment.

Finally, modified MMA patients reported dissatisfaction with the appearance of their lower (Mean 4.19, P<0.05) and upper jaw (Mean 3.56, P=0.156) before surgery and expressed satisfaction with the subsequent changes in their facial appearance: Upper Jaw (Mean 3.56, P=0.150) and Lower Jaw (Mean 3.56, P=0.135). They expressed happiness with the overall transformation (Mean 3.63, P=0.116). Patients were closer to neutral to "increase in their confidence" (Mean 3.25, P=0.615). Our study's findings align with Liao et al.[4]

To examine our null hypothesis, "There is no difference between conventional MMA and modified MMA in their effects on change in quality of life and facial aesthetics for patients with severe obstructive sleep apnea", we have used the Wilcoxon rank sum test. There was a similar trend of improvement in the two surgeries in categories "increased ease of daytime breathing", "better overall health", "greater energy" and "better overall mood", which were statistically significant (P<0.05). However, the most notable category was "better in speech quality". In conventional MMA (Mean 3.71, P<0.05), speech quality improves due to the immediate skeletal change from Class II to Class I. In modified MMA (Mean 2.63, P<0.05), there are immediate changes in pronunciation and speech quality after dental Class I extraction of premolars in conjunction with modified MMA, which changes

the oral cavity's structure and function. These changes affect the positioning and movement of the tongue, lips, and other articulatory organs involved in speech production.

The statistical analysis of facial appearance changes across 7 categories revealed that the observed disparities between the two surgical interventions were statistically insignificant. This outcome implies that the differences observed between the groups are likely attributable to random variations or sampling fluctuations. Consequently, there exists insufficient evidence to support the rejection of the null hypothesis, which postulates the absence of significant differences between the groups under consideration. Considering these findings, it can be inferred that, when comparing the modified MMA group to the conventional MMA group, the modified MMA procedure was equally effective, or at the very least, did not adversely affect the patients' facial appearances.

Despite the surgical and therapeutic benefits of MMA, patients often anticipate aesthetic changes in their facial profile. Furthermore, patients have expressed that their facial profile has indeed improved, leading to increased confidence in their daily lives (Table 2). Consistent with other studies, we have observed significant improvements in sleep quality, daytime function, physical health, mental health, dental function, and recovery (Table 2). [2,3,9,12] Additionally, patients have expressed satisfaction with the facial changes resulting from the surgery (Table 2) similar to findings from studies conducted by Li et al., Liao et al., Liu et al., and Al-Moraissi et al..[4,12,13,15] In a study by Li et al. in 2001, it was reported that 55% of patients expressed satisfaction with their facial appearance.[13] Liu et al. found that 72% of participants favored their facial changes.[12] Al-Moraissi et al. demonstrated that 90%

of patients had a positive or neutral reaction to the changes.[15] Liao et al. reported that Asian participants in their study did not perceive any negative changes in their facial appearance.[4] Similarly, in our study, 92% of patients indicated a positive or neutral stance regarding the overall changes in their facial appearance.

In this study, we included patients who underwent both the conventional MMA, which involved a standard Le Fort I osteotomy and BSSRO with rigid internal fixation, and patients who received modified MMA surgery, which involved a standard Le Fort I osteotomy with ASO and BSSRO with ASO. Previous studies have shown Conventional MMA results in a mean advancement of 7mm of the maxilla and 9mm of the mandible.[11,12] This was similar from the results of our study that the advancement lengths were of a mean of 5.1mm and 8.6mm (Table 2). Modified MMA was much less in the maxillary aspect which from the incisal position, only a mean of 2.4mm was advanced ($P<0.05$) (Table 2). Considering that facial appearance acceptance can vary across countries, particularly in Asia where facial protuberance may be perceived as unaesthetic, it is crucial to assess which surgical approach would best benefit the patient and evaluate the anticipated outcome before surgery.[13.] Most of our patients (a total of 17) underwent modified MMA surgery, aiming to minimize the degree of advancement and protuberance from the incisal position while maximizing the posterior airway space by utilizing the extraction space of premolars. It is important to consider the patient's preference for the procedure before surgery, as aesthetic considerations are subjective.

It is noteworthy that both patients who underwent the conventional method (Mean 3.86; $P<0.05$) and those who underwent the modified method (Mean 3.63; $P<0.001$) expressed satisfaction with the outcomes, despite efforts to minimize

aesthetic compromise resulting from excessive protrusion after conventional MMA. This may be attributed to the fact that the amount of maxillary advancement is less than that of the mandibular, leading to a significant reduction in the skeletal Class II pattern. Li et al. also reported that despite maxillomandibular protrusion being perceived as unaesthetic in Asia, 90% of patients who received conventional MMA surgery had a positive or neutral response to changes in their facial appearance.[13.]

Most of our patients received the modified MMA surgery. By this we can understand that most our patients were not happy with their mouth potentially being protruded after surgery. Since oral surgeons will be working with orthodontists, it is important to communicate with each other to pre-determine the necessity of 1st premolar extractions. Most Skeletal/Dental Class II patients who undergo orthodontic treatment will have their 1st or 2nd premolars removed in order to set back the protruded profile of the teeth thus creating a dental Class I occlusion. If this is done prior to MMA surgery, the patient cannot receive modified MMA but will have to have conventional MMA because the extracted space will be closed. The surgeon and patient, through a thorough evaluation of expectations and reality, it was decided that patient would most benefit from modified MMA. For Class II patients, it would be important for the orthodontist to examine this aspect before starting orthodontic treatment because this gives the patient and surgeon more options. Even though genioglossus advancement is done to relieve OSA symptoms, it may also be beneficial in that it can improve esthetics of the retruded mandible. Genioglossus advancement may also be done to further increase posterior airway space and esthetics after surgery. Despite these predictions and evaluations, both patients

modified and conventional were satisfied with their looks after surgery and the differences were statistically insignificant.

In a study conducted by Butterfield et al., the subjective satisfaction of patients following MMA surgery was investigated using an OSA Questionnaire (Ottawa-questionnaire).[2] Similarly, Cillo et al. utilized the same OSA questionnaire and found significant improvements in personal satisfaction, sleep quality, and functional outcomes.[9] Cillo et al. distinguished their study from Butterfield et al. by extending the follow-up period, thereby demonstrating the long-term (10 years) satisfaction and enhanced quality of life associated with MMA surgery.[9] On another note, although there is overlap between the questionnaire used in our study at Seoul National University Dental Hospital and the ones employed by Butterfield and Cillo et al., certain questions such as "improved desire for sexual intimacy" and "improved relationship with a significant other" were not included in our study. This omission is likely because questions related to sexuality can be deemed offensive or embarrassing to answer in a relatively conservative country, in terms of expressing sexuality, like South Korea, and may not be applicable due to factors such as the lack of a partner, age, or other reasons that we may not be aware of.

Finally, previous studies have identified several significant risk factors for OSA, which include male gender, obesity, advancing age, and anatomically small upper airway.[16] In our study, consistent with the findings of Young et al., there was a higher proportion of male participants compared to females.[16] Additionally, in the study conducted by Boyd et al., 80% of the participants were male (12 men).[11] Our study also confirmed a predominance of male participants, with 70% being men (Table 2), thus reinforcing the substantial role of male gender as a risk factor for OSA.

Furthermore, BMI and obesity were important risk factors, with the average BMI in both conventional and modified MMA groups in our study approximating 25 ($P<0.001$) (Table 2). It is crucial to emphasize the significance of regular exercise and a healthy diet when providing guidance to patients. Notably, participants in our study had relatively lower BMIs compared to individuals in Western countries, where obesity often plays a prominent role in OSA.[10,17] This disparity holds relevance within the Korean population. Although our patients did not exhibit extremely high BMIs, all displayed Skeletal Class II morphology (Table 2). This pattern was also found in a study conducted by Liao et al. among Chinese individuals, which reported an average AHI of 22.4.[4] These findings suggest that Koreans and Asians frequently undergo MMA surgery to treat OSA due to their skeletal morphology rather than solely due to obesity. Furthermore, a study by Zaghi et al. revealed a mean BMI of 33.8 among their patients, Camacho et al found a mean BMI of 44.88, while Cillo et al. found a mean BMI of 39.5, all three significantly higher than the average BMI observed in our study.[9,17,18] Study done by Lee et al and Ong et al. has also confirmed when Caucasians and Asians both had the same BMI, the Asian had a more severe OSA/AHI because of craniofacial bony restrictions compared to Caucasians.[18,19] These findings further support the observation that Asians primarily undergo MMA surgery for OSA treatment based on their skeletal Class II morphology, with obesity playing a relatively lesser role compared to Western countries. In summary, our study, along with previous research, underscores that Asians, particularly those with Skeletal Class II morphology, commonly undergo MMA surgery to address OSA, while obesity playing a less prominent role compared to Western populations.

Age is also a risk factor for OSA. Most studies done in western countries indicate that as age increases, the risk for OSA also increases. The average age for OSA patients in meta-analysis study done by Holty et al, they have shown the average age of OSA patients in 22 studies was 44.4.[10] However, the mean age of OSA patients in our study was 32 ($P<0.01$) (Table 2). In other countries, OSA is well known to be a serious disease, and people are more prepared to endure the associated challenges. In Korea, although the awareness of OSA has improved compared to the past, there is still a lower perception and greater fear of undergoing maxillomandibular advancement surgery for sleep apnea for older patients.

This study was subject to several limitations that warrant consideration. First, the uneven distribution of patients undergoing conventional and modified MMA surgeries may have introduced bias into the data, potentially influencing the results. Moreover, the small sample size employed in this study might have compromised its statistical power, leading to decreased sensitivity in detecting meaningful effects and potentially amplifying sampling variability. To enhance future investigations in this field, several improvements can be implemented. First, an analysis of objective changes in conjunction with subjective evaluations could be conducted to elucidate the correlation between patients' subjective perceptions and the actual objective changes resulting from the surgery. This approach would provide a more comprehensive understanding of the outcomes and their impact on patients' experiences. Furthermore, refining the survey methodology could contribute to more insightful findings. Specifically, allowing patients to articulate specific aspects of the facial changes they found dissatisfying for each category would provide more nuanced and detailed information. This would facilitate a deeper understanding of the

factors influencing patients' perceptions of the surgical outcomes. Additionally, transforming the study from a retrospective design to a prospective one would bolster its strength. A prospective study design would allow for the collection of data in real-time, minimizing recall bias and enhancing the accuracy and reliability of the findings. By following patients longitudinally, researchers could capture a more comprehensive picture of the effects of the surgical interventions over time. In summary, addressing these limitations and incorporating the suggested improvements in future research endeavors would enhance the validity, reliability, and comprehensiveness of the findings in the domain of quality of life and facial appearance changes resulting from MMA surgeries.

To conclude, MMA is an effective treatment that dramatically improves the quality of life of OSA patients. Additionally, modified MMA itself is aimed at minimizing the protrusion of the jaw for patients who already have a protruded maxillomandibular complex. Through this surgery, it was observed that there were no cases that caused a more protruded mouth, and patients reported either improvement or prevention of a compromised facial esthetics, as well as enhanced facial appearance. The modification focuses on minimizing worsening, avoiding negative changes through a counterclockwise rotation of the lower jaw, minimal advancement of the upper jaw, and protrusion of the mandible without compromising facial aesthetics, leading to patient satisfaction.

References

1. Vijayan, VK. Morbidities associated with obstructive sleep apnea. *Expert Review of Respiratory Medicine*, *2012; 6(5):* 557–566

2. Butterfield KJ, Marks PL, McLean L, et al. Quality of life assessment after maxillomandibular advancement surgery for obstructive sleep apnea. *J. Oral Maxillofac. Surg. 2016; 74*:1228.

3. Dolan JM, Weyh AM, Gome J, et al. Commentary: Maxillomandibular advancement for obstructive sleep apnea is associated with very long-ter overall sleep-related quality of life improvement. *J. Oral Maxillofac. Surg. 2020; 78(4):* e1–e4.

4. Liao YF, Chiu YT, Lin CH, et al. Modified maxillomandibular advancement for obstructive sleep apnoea: towards a better outcome for Asians. *Int. J. Oral Maxillofac. Surg. 2015; 44*: 189–194.

5. Iftikhar, IH, Khan, MF, Das A, et al. Meta-analysis: Continuous positive irway pressure improves insulin resistance in patients with sleep apnea without diabetes. *Annals of the American Thoracic Society, 2013; 10(2),* 115–120.

6. Zhang M, Liu Y, Liu Y, et al. Effectiveness of oral appliances versus continuous positive airway pressure in treatment of OSA patients: An updated meta-analysis. *CRANIO® The Journal of Craniomandibular and Sleep Practice 2019; 37(6),* 1–18.

7. Virk J, Kotecha B. When continuous positive airway pressure (CPAP) fails, *Journal of Thoracic Disease*, *2016*; 8(10).

8. Varghese, R, Adams, NG, Slocumb NL, et al. Maxillomandibular advancement in the management of obstructive sleep apnea. *International Journal of Otolaryngology, 2012*; 1–8.

9. Cillo JE, Robertson N, Dattilo DJ. Maxillomandibular advancement for Obstructive sleep apnea is associated with very long-term overall sleep related quality of life improvement. *J. Oral and Maxillofac. Surg. 2020; 78*: 109–17.

10. Holty JEC, Guilleminault C. Maxillomandibular advancement for the treatment of obstructive sleep apnea: A systematic review and meta-analysis. *Sleep Medicine Reviews, 2010; 14(5),* 287–297.

11. Boyd SB, Walters, AS, Waite P, et al. Long-term effectiveness and safety of maxillomandibular advancement for treatment of obstructive sleep apnea. *Journal of Clinical Sleep Medicine. 2015; 11(7)*. 699-708

12. Liu SR, Yi HL. Guan J, et al. Changes in facial appearance after maxillomandibular advancement for severe obstructive sleep apnea hypopnea syndrome in Chinese patients: a subjective and objective evaluation. *Int. J. Oral Maxillofac. Surg. 2012;* 41: 1112–1119.

13. Li KK, Riley RW, Powell NB, et al. Patient's perception of the facial appearance after maxillomandibular advancement for obstructive sleep apnea syndrome. *J. Oral Maxillofac. Surg. 2001, 59(4)*, 377–380.

14. Lee, JE, Lee CH, Lee SJ, et al. Mortality of patients with obstructive ssleep apnea in Korea. *J. of Clinical Sleep Medicine, 2013; 09(10):* 997–1002.

15. Al-Moraissi EA, Wolford LM. Is Counterclockwise rotation of the maxillomandibular complex stable compared with clockwise rotation in the correction of dentofacial deformities? A ssystematic review and meta-analysis. *J. Oral Maxillofac. Surg, 2016; 74(10)*, 2066.e1–2066.e12.

16. Young T, Peppard PE, Gottlieb DJ. Epidemiology of obstructive sleep apnea. *American Journal of Respiratory and Critical Care Medicine, 2002; 165(9)*, 1217-1239.

17. Zaghi S, Holty JEC, Certal V, et al. Maxillomandibular advancement for treatment of obstructive sleep apnea. *JAMA Otolaryngology–Head & Neck Surgery, 2016; 142(1), 58.*

18. Ong KC, Clerk AA. Comparison of the severity of sleep-disordered breathing in Asian and Caucasian patients seen at a sleep disorders center. *Respir. Med. 1998*; 92:843-8.

19. Lee RWW, Vasudavan S, Hui DS, et al. Differences in craniofacial structures andobesity in Caucasian and Chinese patients with obstructive sleep apnea. *Sleep, 2010; 33(8),* 1075–1080.

Table 1. 28 questions on change in Quality of life and Facial appearance

Categories	Variable
Sleep quality	Decreased use of sleeping pills
	Reduced frequency of waking up to urinate
	Reduced frequency of night walking
	Reduced frequency of snoring
	Improved sleep quality
	Reduced Obstructive sleep apnea
Daytime function	Improved concentration
	Improved ability to stay awake
Physical health	Increased ease of daytime breathing
	Better overall health
	Greater energy
Mental health	Improved relationships
	Better mood
	Reduced stress over sleep arrangements
Recovery	Better in speech quality
	Better swallowing ability
	Less headaches
	Pain after surgery
Dental function	Occlusion after surgery
	TMJ after surgery
	Improved teeth alignment
Facial aesthetics	Did not like appearance of lower jaw before surgery
	Did not like appearance of upper jaw before surgery
	Was not confident of looks before surgery
	Happy with how my lower jaw has changed
	Happy with how my upper jaw has changed
	Gained confidence of the way I look
	Like the overall change of the way I look

Table 2. Demographics and medical records

	Con-MMA			Mod-MMA			Con-MMA(control) vs Mod-MMA (Experimental) unpaired T-test		
Category	mean	SD	Range	mean	SD	Range	t-test	SE	P value
Age at surgery, year	30.00	8.16	18-39	32.63	13.79	4- 59	0.47	5.64	P=0.646
AHI (before surgery)	52.20	19.98	28.0 – 76.6	52.23	21.30	23.3 – 85.6	0.004	0.97	P=0.998
AHI (after surgery)	10.40	8.10	3.00 – 22.6	8.89	4.66	1.3 – 22.0	-0.58	2.61	P=0.567
BMI	24.89	6.14	19.5 – 34.3	24.96	3.14	19.9 – 31.2	0.03	1.91	P=0.973
Advancement length (mb cusp 1st molar)	5.00	1.89	2.00 – 7.00	5.34	1.34	3.00 – 7.00	0.46	0.75	P=0.652
Advancement length (incisal edge)	5.00	1.89	2 .00 – 7.00	2.43	1.38	0.00 – 5.00	-3.41	0.75	P=0.003
BSSRO advancement (right)	7.05	2.05	5.6 – 8.5	8.90	2.30	4.9 – 12.7	1.07	1.72	P=0.299
BSSRO advancement (left)	6.65	1.90	5.3 – 8.0	8.27	2.50	4.8 – 5.3	0.87	1.86	P=0.395
Maxillo-mandibular Fixation, wk	3.93	2.72	2.00 – 5.86	5.77	0.95	3.85 – 7.29	1.90	0.97	P=0.867

Unpaired T-test; SD: Standard Deviation; Con-MMA: Conventional MMA; Mod-MMA: Modified MMA; SE: Standard Error

Table 3. Patient responses on Quality of Life
(Conventional MMA; N=7 vs. Modified MMA; N=17)

Categories	Variable	Con-MMA			Mod-MMA			Con-MMA vs Mod-MMA
		Mean	SD	P-value	Mean	SD	P-value	P-value
Sleep quality	Decreased use of sleeping pills	4.43	0.98	<0.05 **	3.69	1.14	<0.05**	0.149
	Reduced frequency of waking up to urinate	4.14	0.90	<0.05 **	3.56	1.03	<0.05**	0.237
	Reduced frequency of night walking	4.43	0.53	<0.05 **	3.81	1.11	<0.05 **	0.246
	Reduced frequency of snoring	4.43	0.53	<0.05 **	4.25	0.93	<0.05**	0.912
	Improved sleep quality	4.57	0.53	<0.05 **	4.44	0.73	<0.001***	0.820
	Reduced Obstructive sleep apnea	4.57	0.53	<0.05 **	4.19	0.91	<0.05**	0.399
Daytime function	Improved concentration	4.00	0.58	<0.05 **	3.50	0.73	<0.05**	0.121
	Improved ability to stay awake	4.00	0.58	<0.05 **	3.69	0.87	<0.05**	0.387
Physical health	Increased ease of daytime breathing	4.57	0.53	<0.05 **	3.88	0.72	<0.05**	<0.05**
	Better overall health	4.57	0.53	<0.05 **	3.56	0.73	<0.05**	<0.05**
	Greater energy	4.57	0.53	<0.05 **	3.63	0.72	<0.05**	<0.05**
Mental health	Improved relationships	4.14	0.38	<0.05 **	3.25	0.58	0.174	<0.05**
	Better mood	4.57	0.53	<0.05 **	3.75	0.68	<0.05**	<0.05**
	Reduced stress over sleep arrangements	4.57	0.53	<0.05 **	3.94	1.12	<0.05**	0.233
Recovery	Better in speech quality	3.71	0.49	<0.05 **	2.63	0.89	0.124	<0.05**
	Better swallowing ability	3.86	0.38	<0.05 **	3.38	0.96	0.160	0.189
	Less headaches	3.71	0.76	<0.05 **	3.69	1.01	<0.05**	0.911
	Pain after surgery	2.86	1.68	0.0726	3.31	1.08	0.276	0.491
Dental function	Occlusion after surgery	3.43	0.98	0.345	3.56	0.89	<0.05**	0.802
	TMJ after surgery	3.86	0.38	<0.05 **	3.75	1.06	<0.05**	0.906
	Improved teeth alignment	3.43	0.79	0.233	4.00	1.37	<0.05**	0.133
Facial aesthetics	Did not like appearance of lower jaw before surgery	3.57	1.27	0.279	4.19	0.98	<0.05**	0.258
	Did not like appearance of upper jaw before surgery	2.71	0.76	0.424	3.56	1.26	0.156	0.067
	Was not confident of looks before surgery	3.00	1.15	<0.05 **	3.25	1.06	0.390	0.508
	Happy with how my lower jaw has changed	4.00	0.82	<0.05 **	3.56	1.31	0.150	0.599
	Happy with how my upper jaw has changed	3.57	0.53	<0.05 **	3.56	1.21	0.135	0.692
	Gained confidence of the way I look	3.86	0.69	<0.05 **	3.25	1.29	0.615	0.338
	Like the overall change of the way I look	3.86	0.69	<0.05 **	3.63	1.26	0.116	0.915

Likert scale using One-sample Wilcoxon signed-rank test and Wilcoxon rank sum test with statistical computing program R and Excel; SD: Standard Deviation; Con-MMA: Conventional MMA; Mod-MMA: Modified MMA

Table 3. Patient responses on Facial appearance
(Conventional MMA; N=7 vs. Modified MMA; N=17)

Categories	Variable	Con-MMA			Mod-MMA			Con-MMA vs Mod-MMA
		Mean	SD	P-value	Mean	SD	P-value	P-value
Facial aesthetics	Did not like appearance of lower jaw before surgery	3.57	1.27	0.279	4.19	0.98	<0.05 **	0.258
	Did not like appearance of upper jaw before surgery	2.71	0.76	0.424	3.56	1.26	0.156	0.067
	Was not confident of looks before surgery	3.00	1.15	<0.05 **	3.25	1.06	0.390	0.508
	Happy with how my lower jaw has changed	4.00	0.82	<0.05 **	3.56	1.31	0.150	0.599
	Happy with how my upper jaw has changed	3.57	0.53	<0.05 **	3.56	1.21	0.135	0.692
	Gained confidence of the way I look	3.86	0.69	<0.05 **	3.25	1.29	0.615	0.338
	Like the overall change of the way I look	3.86	0.69	<0.05 **	3.63	1.26	0.116	0.915

Likert scale using One-sample Wilcoxon signed-rank test and Wilcoxon rank sum test with statistical computing program R and Excel; SD: Standard Deviation; Con-MMA: Conventional MMA; Mod-MMA: Modified MMA

Figure 1. Patient responses on QOL and facial appearances
(Conventional MMA patients; N=7)

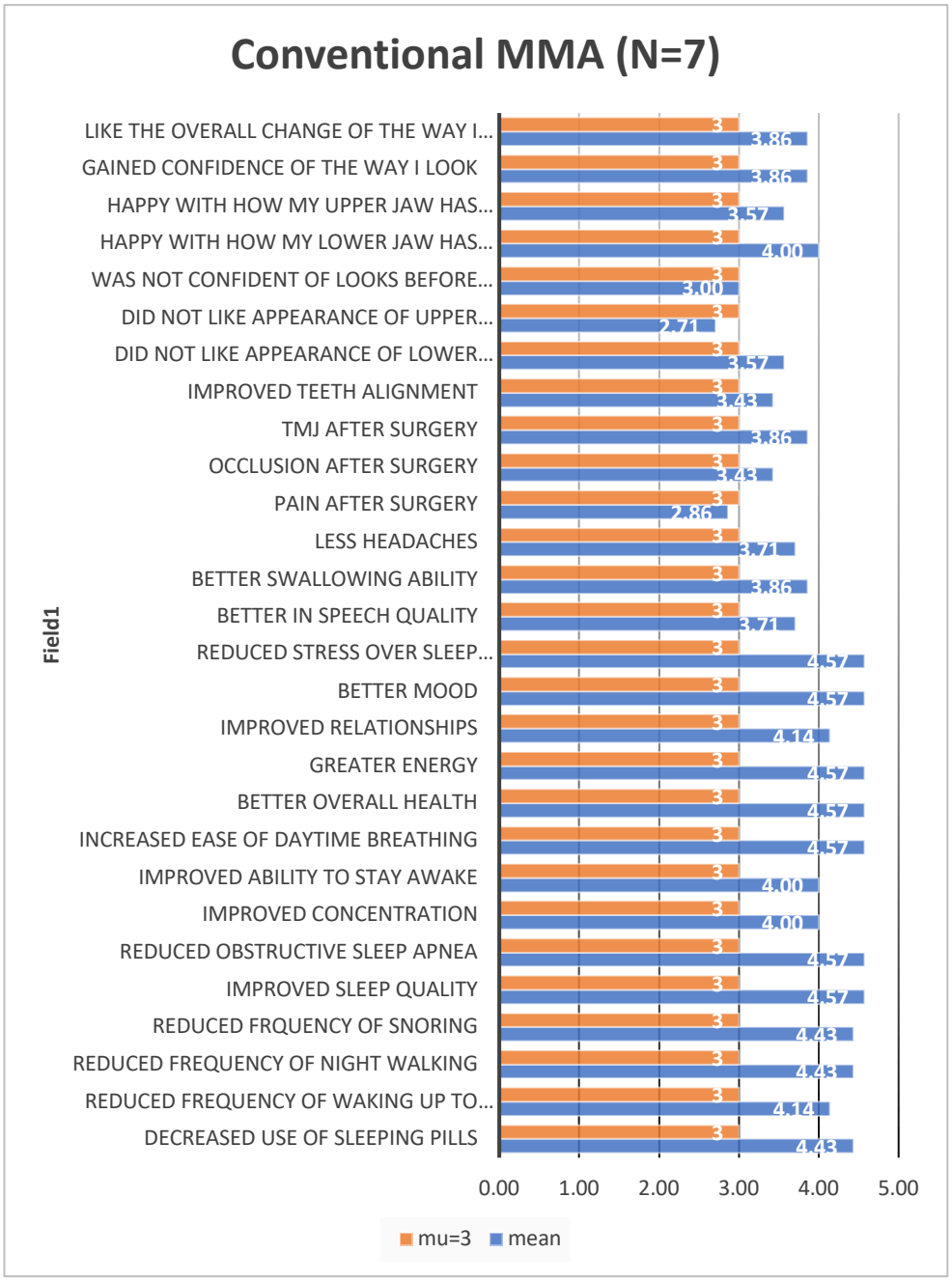


Figure 2. Patient responses on QOL and facial appearances
(Modified MMA patients; N=17)

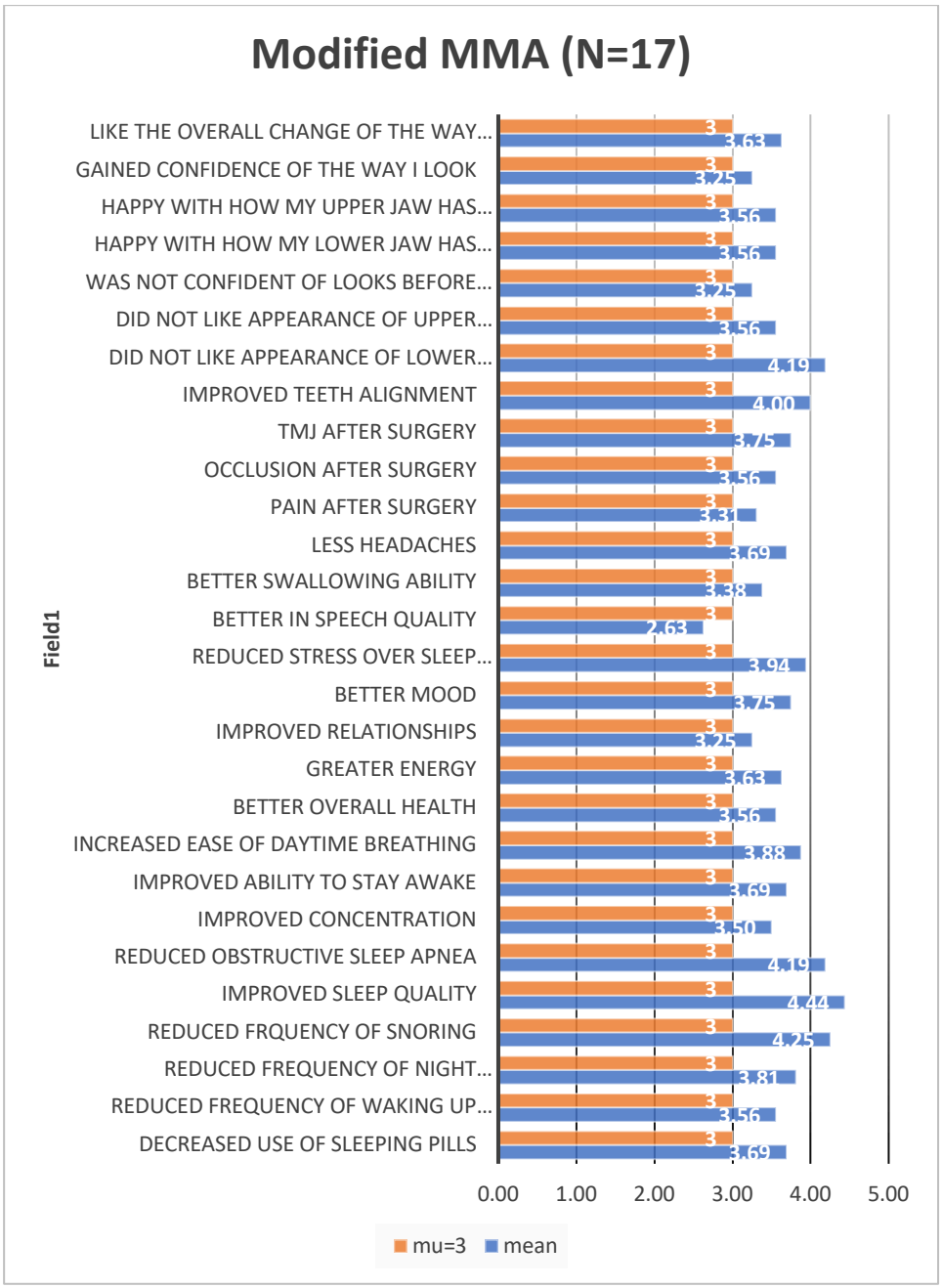
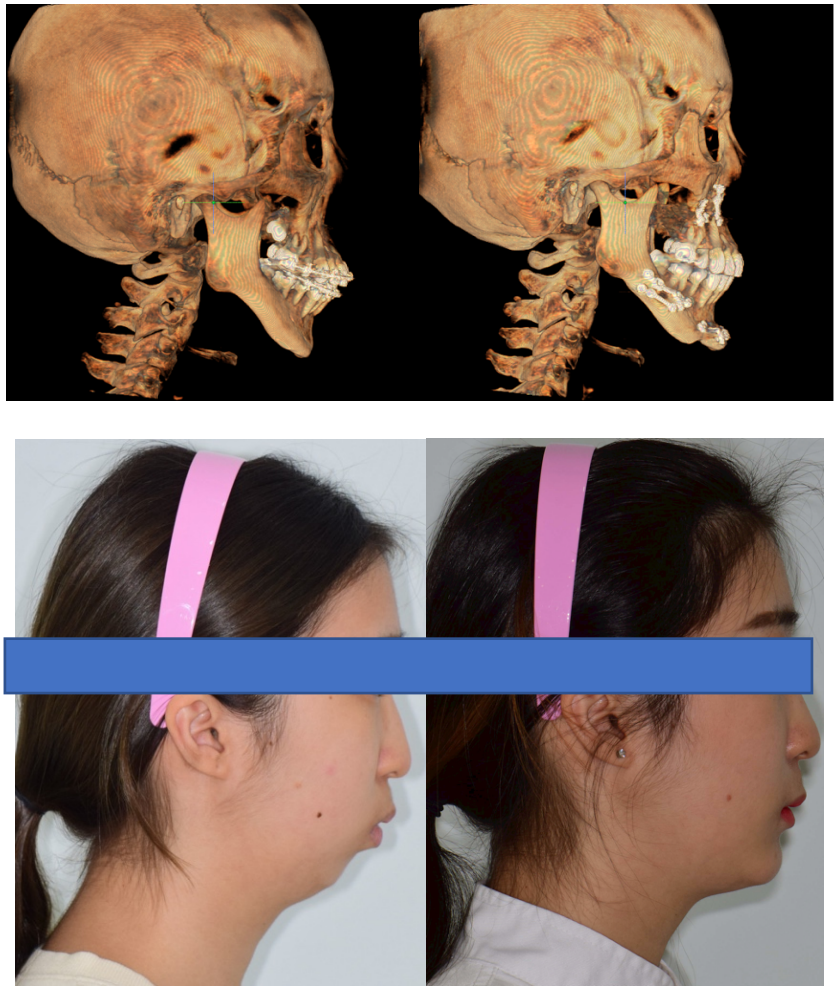


Figure 3. Conventional MMA and genioglossus advancement (Case 1).

Figure 4. Modified MMA and genioglossus advancement (Case 2).

Figure 5. Conventional MMA and Genioglossus advancement (Case 3)



초 록

목적: 본 연구의 목적은 수면무호흡증 치료를 위한 변형된 양악전진술이 기존의 전통적 양악전진술에 비해 수술 후 환자의 삶의 질과 얼굴의 심미성 변화에 미치는 효과를 후향적으로 평가하고 비교하는 것이다.

방법: 2013년 1월 1일부터 2022년 12월 31일까지 양악 전진술을 받고 중등도에서 중증 수면무호흡증 진단을 받은 환자 (AHI가 15 이상인 환자)들의 의무기록 및 수술 후 삶의 질 개선과 심미적 안면 외모에 대한 변화에 대한 28개의 질의응답 결과를 종합하였다. 환자들의 대답에는 리커트 척도(Likert scale)와 1표본 윌콕슨 부호 순위 검정 (one sample Wilcoxon signed rank test)을 사용하여 후향적으로 조사하였고, 3은 변화가 없음, 4와 5는 삶의 질과 안면 외모에 대한 만족을, 1과 2는 감소를 의미하였다. 이에 평균 및 표준편차를 계산하였으며, 각 항목에 대한 P값이 0.05 이하일 때 통계적으로 유의미 하다고 판단하였다. 또한 전통적 양악전진술과 변형된 양악전진술이 수술 후 환자의 삶의 질과 얼굴의 심미성 변화에 미치는 효과의 차이를 비교분석하기 위해 윌콕슨 순위합 검정 (Wilcoxon rank sum test)을 사용 하였고 이에 대해서도 각 항목에 대한 P값이 0.05 이하일때 통계적으로 유의미 하다고 판단하였다. 마지막으로, 3가지 대표 사례를 선정 후 사례를 검토 하였다.

결과: 모든 환자는 골격성 II급 부정 교합이었다. 24명의 환자 중 17명이 남성이고 7명이 여성이었다. 24명 중 17명은 변형된 양악전진술을 받았으며 7명은 전통적 양악전진술을 받았다. 수술 시 평균 연령은 32.6 ± 10.9세였으며, 수술 전 평균 AHI는 51.7±21.6, 수술 후 평균 AHI는 9.5±7.78이였다. 상악 전방 전진량 평균은 전통적 양악전진술 5.00±2.12mm, 그리고 변형된 양악전진술은 2.39±1.42mm였다 (상악 중절치 절단면 기준). 전통적 양악전진술을 받은 환자들의 하악 우측 평균 전진량은 하악지 시상분할 절골술 후 7.05±2.05mm 이었고 하악 좌측은 6.65±1.90mm이었고, 변형된 양악전진술을 받은 환자들의 하악 우측 평균 전진량은 8.90±2.20mm 이었고 하악 좌측은 8.17±2.50mm 이었다 (6번 근심협측 교두 기준). 전통적 양악전진술을 받은 환자들은 수면의 질, 일상 기능, 신체 건강, 정신 건강, 교합기능, 술 후 회복 및 얼굴 심미성 ($P<0.05$)에 대해 개선 되었다고 응답하였고 변형된 양악전진술을 받은 환자들은 수면의 질, 일상 기능, 신체건강, 교합기능에 대해 개선($P<0.05$) 되었다고 응답하였고 얼굴 심미성에 대해서도 개선 되었다고 응답하였으나 통계적 의미는 없었다 ($P=0.446$).

전통적 양악전진술과 변형된 전진술이 불러오는 수면 무호흡증 환자의 삶의 질과 얼굴 외모 변화의 차이를 분석한 결과, 다음 항목에서 통계적으로 유의미하였다: "숨쉬기가 더 편해졌다", "전체적으로 건강해진 느낌을 받는다", "에너지가 더 많아진 것 같다", "전반적인 기분이 좋아졌다", "발음/발성이 좋아졌다" ($P<0.05$). 그러나 다음 얼굴의 심미성 변화에 대한

항목에서 두 수술방법간 차이가 통계적으로 유의미하지 않았다: "수술 전 아래턱의 모습이 마음에 들지 않았다" (P=0.258), "수술 전 위턱의 모습이 마음에 들지 않았다" (P=0.067), "수술 전 외모에 자신감이 없었다" (P=0.508), "수술 후 아래턱의 변화에 만족한다" (P=0.599), "수술 후 위턱의 변화에 만족한다" (P=0.692), "외모에 대한 자신감이 상승했다" (P=0.338), "전반적인 안모/외모 변화에 만족한다" (P=0.915).

결론: 양악 전진술은 환자의 삶의 질을 향상시키는 데 도움이 되며, 안면 외모 또한 개선되거나 악화 되지는 않았다. 변형된 양악 전진술은 외모의 악화로 인해 상악을 충분히 전진 시킬 수 없는 경우 상기도의 공간을 확보하면서 상하악 복합체의 돌출을 줄이고 수술 후 삶의 질과 안면 외모 만족도를 최소한 악화시키지 않는다.

주요어: 수면무호흡증, 전통적 양악전진술, 변형된 양악 전진술, 삶의 질, 안면 외모, 심미

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