J Surg Med. 2020;4(3):207-211.
DOI: 10.28982/josam.702532

Research article
Araştırma makalesi

Journal of Surgery and Medicine
e-ISSN=2602-2079

Investigating the role of nasal muscles in nasal obstruction after open technique rhinoplasty: A case-control study by electromyographic evaluation

Açık teknik rinoplasti sonrası nazal kasların burun tıkanıklığındaki rolünün araştırılması: Elektromiyografik değerlendirme ile bir vaka kontrol çalışması

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Ethics Committee Approval: This study was approved by the Istanbul Yeni Yuzyil University (IYYU), Non-Interventional Clinical Research Ethics Board (2/10/2020-2020/02). All procedures in this study involving human participants were performed in accordance with the 1964 Helsinki Declaration and its later amendments.
Etik Kurul Onayı: Bu çalışma İstanbul Yeni Yüzyıl Üniversitesi (IYYU), Girişimsel Olmayan Klinik Araştırmalar Etik Kurulu (10.02.2020-2020/02) tarafından onaylanmıştır. İnsan katılımcıların katıldığı çalışmalardaki tüm prosedürler, 1964 Helsinki Deklarasyonu ve daha sonra yapılan değişiklikler uyarınca gerçekleştirilmiştir.

Conflict of Interest: No conflict of interest was declared by the authors.
Çıkar Çatışması: Yazarlar çıkar çatışması bildirmemişlerdir.

Financial Disclosure: The authors declared that this study has received no financial support.
Finansal Destek: Yazarlar bu çalışma için finansal destek almadıklarını beyan etmişlerdir.

Published: 3/27/2020
Yayın Tarihi: 27.03.2020

Abstract

Aim: Although the effects of rhinoplasty on nasal muscles by electromyography (EMG) or electroneuronography have been studied, the role of the nasal muscles in nasal obstruction after rhinoplasty operations has not yet been investigated. The aims of this study were to investigate the influence of the open rhinoplasty on nasal muscles and to reveal the role of the nasal muscles in post-operative nasal obstruction.

Methods: Thirty-five patients who underwent open technique rhinoplasty by a single surgeon due to external nasal deformity were included in the study. The patients were divided into two groups six months after the surgery: Study group with nasal obstruction and control group without nasal obstruction. EMG was performed to all patients for the activity of M. procerus, M. transversus nasalis and M. dilator before and after rhinoplasty.

Results: It was observed that the amplitudes of M. transversus nasalis and M. dilator muscles in the patients with nasal obstruction were significantly lower than the patients without nasal obstruction (P=0.01, P=0.003, respectively). Post-operative electromyographic activities of nasal muscles significantly decreased in all patients compared to pre-operative amplitudes.

Conclusion: This study demonstrated that nasal muscles or SMAS may be damaged during open technique rhinoplasty and as a result of this damage (especially in M. transversus nasalis and M. dilator) nasal respiration can be affected, which may lead to post-operative nasal obstruction. Preservation of these muscles and SMAS during rhinoplasty operations may reduce the incidence of post-operative nasal obstruction.

Keywords: Rhinoplasty, Intrinsic nasal muscles, Electromyography, Nasal obstruction

Öz

Amaç: Rinoplastinin nazal kaslar üzerine etkisi elektromyografi (EMG) veya elektronöronografi ile çalışılmış olsa da, rinoplasti operasyonu sonrası burun tıkanıklığında nazal kasların rolü henüz araştırılmamıştır. Bu nedenle bu çalışmanın amacı açık rinoplastinin nazal kaslar üzerine etkilerini incelemek nazal kasların operasyon sonrası burun tıkanıklığındaki rolünü ortaya koymaktır.

Yöntem: Çalışmaya eksternal nazal deformite nedeniyle tek bir cerrah tarafından açık teknik rinoplasti uygulanan otuz beş hasta dahil edilmiştir. Hastalar cerrahiden altı ay sonra; burun tıkanıklığı olan çalışma grubu ve burun tıkanıklığı olmayan kontrol grubu olmak üzere iki gruba ayrılmıştır. Tüm hastalara rinoplasti öncesi ve sonrasında m. procerus, m. transversus nasalis ve m. dilator aktivitelerinin ölçülmesi için EMG uygulanmıştır.

Bulgular: Burun tıkanıklığı olan hastalarda m. transversus nasalis ve m. dilator kaslarının amplitüdlerinin burun tıkanıklığı olmayanlara göre anlamlı düzeyde düşük olduğu saptandı (srasıyla; P=0,01, P=0,003). Cerrahi sonrası tüm hastalarda nazal kasların elektromiyografik aktivitesi cerrahi öncesi amplitüdleri ile kıyaslandığında anlamlı düşüş gösterdi.

Sonuç: Bu çalışma nazal kasların veya SMAS'ın açık teknik rinoplasti ile hasar görebileceğini; bu hasarın sonucunda (özellikle m. transversus nasalis ve m. dilator) nazal solunumun etkilenebileceğini ve cerrahi sonrası burun tıkanıklığı gelişebileceğini ortaya koymaktadır. Rinoplasti operasyonu süresince bu kasların ve SMAS'ın korunması cerrahi sonrası burun tıkanıklığı insidansını düşürebilir.

Anahtar kelimeler: Rinoplasti, İntrensek nazal kaslar, Elektromyografi, Burun tıkanıklığı

How to cite/Atıf için: Resuli AS, Ataus S. Investigating the role of nasal muscles in nasal obstruction after open technique rhinoplasty: A case-control study by electromyographic evaluation. J Surg Med. 2020;4(3):207-211.

Introduction

Although rhinoplasty is one of the most difficult aesthetic surgeries, the number of rhinoplasty operations has increased considerably in recent years. According to the annual report of American Society of Plastic Surgeon, rhinoplasty was the most common surgery performed among men in 2018, while it was the fourth most common surgical operation among women [1]. Because of aesthetic concern in rhinoplasty, more importance has been given to osseocartilaginous structure. However, both the aesthetic appearance and functional results must be considered when evaluating rhinoplasty outcomes. Recently, studies have increased investigating how nasal functions will be affected while achieving aesthetic outcome in rhinoplasty operations. Nasal obstruction is one of the most important post-operative (post-op) complaints in rhinoplasty. While 25 to 40% of rhinoplasty patients consult an aesthetic surgeon for revision surgery, 68% of patients complain of nasal obstruction after the operation [2-4].

The nose has many dynamic functions such as breathing and participating in facial mimic movements. The nasal muscles on the side walls of the nose provide these functions. These muscles are divided into two, intrinsic and extrinsic muscles. Intrinsic muscles including M. nasalis, M. dilatores naris anterior, M. procerus and M. depressor septi nasi are entirely within the nose and the bundles of extrinsic muscles including M. levator labii ala nasi, M. zygomaticus minor and M. orbicularis oris stretch out from the nose [5] (Figure 1). All these nasal muscles are located in a soft tissue called superficial musculoaponeurotic system (SMAS) [6]. The SMAS allows the distribution of forces resulting from contractions of multiple muscles. Each nasal muscle is interconnected by its fascia and a nasal SMAS component, thereby balancing the movement of the muscles [7]. It was stated that this layer may be damaged in rhinoplasty operations while it is dissected along with the dorsal nasal flap [8]. If this layer is damaged, the movement in these muscles, hence, the nasal movement will be affected, and the nose will become paralytic. This paralysis can be one of the causes of nasal obstruction, which is a complication of rhinoplasty.

Electromyography (EMG) is the best method to measure the functions of nasal muscles before and after surgery and to evaluate the muscular damage that may occur. In electromyographic evaluation using surface electrodes, it was possible to selectively distinguish the different electrical activities of each muscle despite the small size of the nasal muscles [9].

Although the effects of rhinoplasty on nasal muscles have been investigated by EMG or electroneuronography (ENoG) so far, the relationship between nasal obstruction after rhinoplasty and damage to nasal muscles in surgery has not yet been investigated. The aims of this study were to evaluate the influence of the rhinoplasty on nasal muscles, investigate the causes of post-op nasal obstruction in patients who underwent nasal hump reduction only because of aesthetic concern, reveal the role of the nasal muscles in post-op nasal obstruction and which muscle would have the greatest effect on this dysfunction.

Materials and methods

The study was conducted with 35 patients who underwent open technique rhinoplasty by a single surgeon due to external nasal deformity in Istanbul Yeni Yuzyil University and Bahat Hospital Otolaryngology and Throat Clinics between 2018 and 2019. After rhinoplasty operation the patients were divided into two groups as study group who had nasal obstruction complaints in the 6th post-operative month and control group who did not have any nasal obstruction complaints. The principles of the Declaration of Helsinki and Guidelines for Good Clinical Practices were followed during the study. The permission was obtained from the patient (in figure 2) to use her photograph in the article. This study was approved by Istanbul Yeni Yuzyil University (IYYU), Non-Interventional Clinical Research Ethics Board (2/10/2020-2020/02) and written informed consent was obtained from the patients after detailed explanations regarding the procedure were given.

Patients having complaints of nasal obstruction, dynamic nasal valve collapse by detailed nasal endoscopic examination, static nasal valve collapse by modified Cottle maneuver, nasal surgery prior to study, acute or chronic sinusitis, nasal polyps, facial paralysis, and myopathies were excluded from the study. Patients who were over 18 years of age and underwent planned open technique rhinoplasty due to external nasal deformity with only aesthetic concerns were included. All patients were evaluated by a neurologist and confirmed that they did not have any myopathies. The research was within the scope of seventy of our patients. 35 patients were excluded due to pre-op nasal congestion (n=12), sinusitis or nasal polyp (n=5), previous nasal surgery (n=11), static or dynamic nasal valve collapse (n=4) and missing control visits (n=3). Consequently 35 patients were included in the study.

Electromyography

Three major nasal intrinsic muscles (M. procesus, M. transversus nasalis, M. dilator naris anterior) were studied bilaterally in EMG preoperatively and in the 6th postoperative month. EMG was performed by our hospital neurologist using Medelec Syrerg N EP-EMG (EP monitoring system + Viasys Healthcare, Madisan, WI). During the analyses, the low filter was set at 500 Hz and the high filter at 1500 Hz. Recordings were studied bilaterally, and the arithmetic mean of bilateral amplitudes were calculated.

Functions of the nasal muscles were assessed in response to voluntary movements of the nose in these patients before and 6-7 months after open rhinoplasty. The EMG activities of the 3 intrinsic muscles (the procerus, transverse part of the nasalis muscle, and the dilator naris anterior) on both sides of the nose were recorded continuously. Three pairs of modified disposable bipolar surface electrodes were used after cleaning the skin with alcohol and ether. Short-circuiting was avoided with the application of the gel. Each pair of electrodes was placed on the nasal skin in such a way that they selectively recorded the activity of these muscles. Bipolar recordings were taken after the related electrodes were placed about 1 cm apart over the muscles to be investigated. As the muscle lengths were small, electrode placement was standardized on the subject as follows: For the procerus, active and reference electrodes were placed 0.5cm and 1.5cm below the glabella, respectively. The transverse part of the nasalis muscle was tested with an active electrode placed at the rhinion and a reference electrode placed 1 cm below the rhinion. For dilator naris anterior muscle, an active electrode was placed on the ala close to the rim, and a reference electrode was attached 1 cm above the active electrode. The electrodes were fixated mechanically with the thin and short adhesive tape so that it did not interfere with nasal movements. EMG recording were made under the following conditions: a. Rhythmic widening of the nostril (nasal flaring), b. forced nasal inspiration, c. gentle closure of the eye, and d. lifting the nasal tip while frowning. Each movement was recorded 3 times for the each side of the nose. The highest amplitude levels of the bursts (interference pattern) were considered for the preoperative and postoperative measurements. At the end of each testing session, electromyographic recordings were also made in relaxed position to substantiate any spontaneous activity (Figure 2).

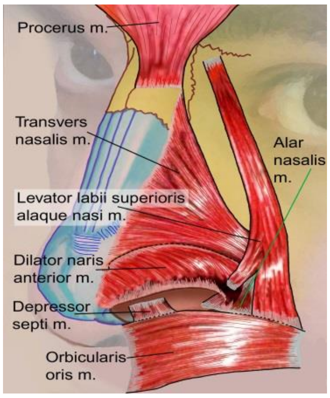

Figure 1: Intrinsic nasal muscles


Figure 2: Conducting an electromyographic test

Surgical technique

The open rhinoplasty operation was performed to all patients beginning with a transcolumellar V incision. The incision was extended by staying in the subcutaneous plane until the medial crura. Care was taken not to damage the soft tissue on the columellar flap and between the medial crura. The perichondrium of the middle crura was cut with sharp tip scissors. Elevation was extended in the subperichondral plane with the help of elevators. Caudal subperichondral dissection was continued until the fronto-nasal connection was reached while remaining in the subperiosteal plane. Facial nerve branches stimulating the nasal muscles were preserved under the SMAS layer. After completing the hamp resection and lateral osteotomies, the septal mucopericondrium was bilaterally elevated and septal cartilage graft was taken for use in nasal reconstruction and tip plasty. The incisions were closed by suturing and the operation was completed.

Statistical analysis

The analysis was performed using SPSS Statistics 20 software. The data were reported as mean (standard deviation) (SD). The normality analyses showed that the groups did not show normal distribution. Therefore, Mann Whitney U test was used to compare the means of independent groups and Wilcoxon test was used to compare the mean of dependent groups. *P*-value <0.05 was considered statistically significant.

Results

According to inclusion criteria, 35 patients were eligible for the study. Nineteen (54.3%) of them were included in the study group due to nasal obstruction after the 6th postoperative month and 16 (45.7%) were included in the control group due to lack of nasal obstruction complaints. The mean age of the patients in the study and control groups were 25.4 (5.25) years and 27.1 (6.83) years, respectively. The characteristics of the patients were given in Table 1.

Comparisons of the EMG amplitudes of M. procerus, M. transversus nasalis and M. dilator at the sixth postoperative months between the study group with post-op nasal obstruction and the control group without nasal obstruction were depicted in Table 2. While the amplitudes of the M. procerus muscle were not significantly different between the groups (*P*=0.39 at right, *P*=0.11 at left, *P*=0.15 at total), it was observed that amplitudes of M. transversus nasalis and M. dilator muscles decreased significantly in the study group (Figure 3) compared to the control group (*P*=0.01, *P*<0.01; respectively) (Figure 4) (Table 2). The post-op amplitude of M. transversus nasalis was 1.97 mV in the control group while it was 2.08 mV in the study group, and the post-op amplitude of M. dilator was 1.61 mV in the study group while it was 1.91 mV in the study group.

Comparisons of pre-op and post-op EMG results of the study group were depicted in Table 3. Right and left EMG amplitudes of all three muscles were significantly lower in post-op EMG values than pre-op values in study group (all *P*<0.001).

Comparisons of pre-op and post-op EMG results of the control group were depicted in Table 4. Right and left EMG amplitudes of all three muscles were significantly lower in the post-op EMG compared to the pre-op examination in the study group (all *P*<0.001 except left M. dilator *P*=0.03).

Table 1: Characteristics of the patients

	n	%	Age mean (SD) years
Study Group	19	54.3	25.4 (5.25)
Control Group	16	45.7	27.1 (6.83)
Total	35	100	26.3 (5.76)

SD: Standard deviation

Table 2: Comparison of post-op EMG results of study and control groups (Mann Whitney U)

		Study group mean (SD) mV	Control group mean (SD) mV	*P*-value
M. procerus	Right	1.98 (0.54)	1.98 (0.17)	0.39
	Left	2.06 (0.21)	1.91 (0.32)	0.11
	Total	2.08 (0.22)	1.97 (0.18)	0.15
M. transversus nasalis	Right	2.10 (0.20)	2.31 (0.25)	0.01
	Left	2.09 (0.21)	2.33 (0.23)	<0.001
	Total	2.10 (0.19)	2.32 (0.23)	0.01
M. dilator	Right	1.58 (0.29)	1.92 (0.25)	<0.001
	Left	1.63 (0.24)	1.90 (0.22)	0.003
	Total	1.61 (0.19)	1.91 (0.23)	<0.001

Table 3: Comparison of pre-op and post-op EMG results of the study group (Wilcoxon)

		Study group mean (SD) mV		Z	*P*-value
		Pre-op	Post-op		
M. procerus	Right	2.18 (0.26)	1.98 (0.54)	-3.62	<0.001
	Left	2.20 (0.23)	2.06 (0.21)	-3.72	<0.001
M. transversus nasalis	Right	2.21 (0.25)	2.10 (0.20)	-3.38	<0.001
	Left	2.17 (0.19)	2.10 (0.20)	-3.55	<0.001
M. dilator	Right	1.99 (0.29)	1.58 (0.29)	-3.85	<0.001
	Left	2.04 (0.22)	1.63 (0.24)	-3.86	<0.001

Table 4: Comparison of pre-op and post-op EMG results of the control group (Wilcoxon)

		Control group mean (SD) mV		Z	*P*-value
		Pre-op	Post-op		
M. procerus	Right	2.07 (0.22)	1.98 (0.17)	-3.07	<0.001
	Left	2.03 (0.22)	1.91 (0.32)	-2.97	<0.001
M. transversus nasalis	Right	2.38 (0.25)	2.31 (0.25)	-2.08	<0.001
	Left	2.47 (0.19)	2.33 (0.23)	-3.45	<0.001
M. dilator	Right	1.98 (0.27)	1.92 (0.25)	-2.88	<0.001
	Left	1.95 (0.21)	1.90 (0.22)	-2.11	0.03

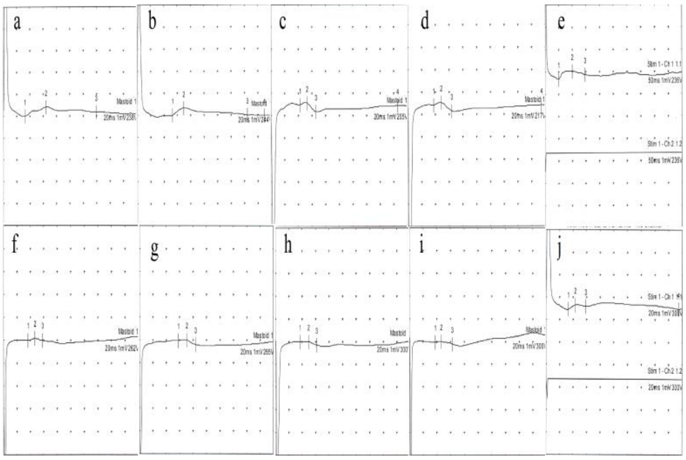

Figure 3: Electromyographic (EMG) results of study (nasal obstruction +) group: a)Pre-op.right m.transvers nasalis, b) Pre-op. left m.transvers nasalis, c)Pre-op. right m. dilator, d) Pre-op. left m. dilator, e) Pre-op. right m. procerus, f) Post-op.right m.transvers nasalis, g) Post-op. left m.transvers nasalis, h)Post-op. right m. dilator, i) Post-op. left m. dilator, j) Post-op. right m. procerus

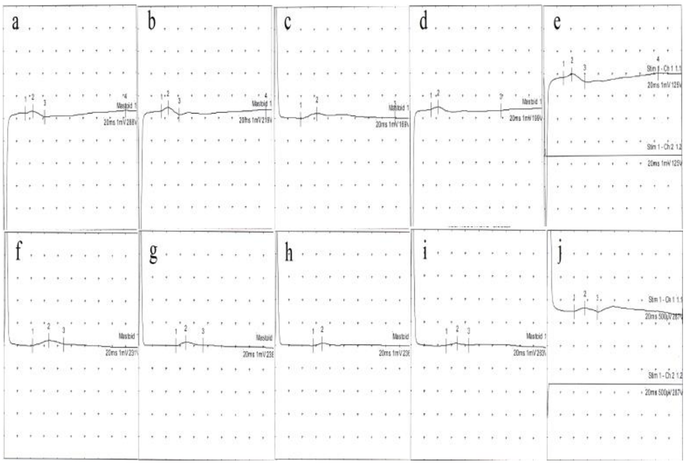

Figure 4: Electromyographic (EMG) results of control (nasal obstruction -) group: a)Pre-op.right m.transvers nasalis, b) Pre-op. left m.transvers nasalis, c)Pre-op. right m. dilator, d) Pre-op. left m. dilator, e) Pre-op. right m. procerus, f) Post-op.right m.transvers nasalis, g) Post-op. left m.transvers nasalis, h)Post-op. right m. dilator, i) Post-op. left m. dilator, j) Post-op. right m. procerus

Discussion

This is the first study to investigate the role of nasal muscles in post-op nasal obstruction. In our study, it was demonstrated that in all patients with nasal hump deformity who underwent open technique rhinoplasty for nasal hump reduction because of aesthetic concern, M. procerus, M. transversus nasalis and M. dilator could be damaged during the operation and particularly damage in M. transversus nasalis and M. dilator muscles could be related to post-op nasal obstruction. The results of present study indicate that the damage in M. transversus nasalis and M. dilator muscles or in the SMAS coordinating these muscles may contribute to post-op nasal obstruction in rhinoplasty cases.

Nose is important in cosmetic appearance and functions of the respiration. The nose is surrounded by nasal musculature, SMAS, perichondrium or periosteum. Nasal muscles have roles in determining phonation, respiration, and facial expression. The muscles that are strongly associated with the inspiratory phase of respiration are pars alaris and pars transversus of M. nasalis and M. dilator naris anterior. They work synergistically, balancing each other's effects [10]. Thus, these muscles can be considered as accessory muscles of respiration. They also take part in voluntary nasal movements [11]. On the other side there are M. procerus and M. levator labii alaquae nasi. These muscles are rarely activated in respiration but show high function in complex mimetic activities [10]. Although there are variations between individuals in intrinsic nasal muscles, M. proserus, M. transvers nasalis and M. dilator are major nasal muscles in humans [7]. Therefore, the protection of nasal muscles in rhinoplasty operations is important not only in cosmetics but also in mimic movements and protection of nasal respiration. However, while aesthetic results are desired in many rhinoplasty operations, the muscular layer and the structures associated with this layer are ignored. Increasing studies investigating the pre-op and post-op electromyographic functions of the nasal muscles will reveal the causes of functional disorders such as nasal obstruction after rhinoplasty and will increase the concern on these structures during the operations.

ENoG and EMG are very valuable methods that can be used to assess the functions of nasal muscles. The potentials of nasal motor units can be recorded from the skin using surface electrodes, although the size of the nasal muscles is very small and can be selectively discriminated between various electrical activities [9]. In the literature, EMG was used in some studies comparing muscle activities before and after rhinoplasty [11,12], while ENoG was used in others [13,14]. Although ENoG provides more information about muscle functions, patient compliance is more difficult because it is performed by external stimulation. In our study, EMG was applied to the patients using superficial electrodes over the skin. High compliance was achieved in all patients. Although there are several published studies about the functions of muscles before and after rhinoplasty with EMG or ENoG, there have been no report investigating the role of nasal muscles in post-op nasal obstruction after rhinoplasty. The function of nasal muscles after rhinoplasty was first investigated in 1983 by Thumfart et al. [12]. They compared the EMG findings of 42 patients before and 2 and 8 months after rhinoplasty and observed a significant decrease in the amplitudes of the nasal muscles in only 2 cases. However, there is not enough information about which technique is used during the operation. In 2001, Ozturan et al. [11] examined the activity of M. procerus, M. transversus nasalis and M. dilator in 21 patients who underwent open technique rhinoplasty and reported that amplitudes decreased significantly in all EMG recordings performed at the 3rd and 5th postoperative months. A study by Kirgezen et al. [13] reported the post-op EMG and ENoG results of 18 endonasal and 30 external rhinoplasty operations. About 6.6% of the closed rhinoplasty group and 11.1% of the open rhinoplasty group showed a decrease in EMG amplitudes of the nasal muscles and significant decreases in post-op amplitudes were found according to ENoG results. In a study by Batioglu-Karaaltin et al. [14] investigating the effect of open rhinoplasty on mimic movements involving 20 patients, a decrease was observed in all amplitudes of bilateral transverse nasal, levator labii superioris alaeque nasi and procerus muscles in the 3rd month following rhinoplasty. However, the significant decrease was found only in the left levator labii superioris alaeque nasi muscle. It was reevaluated at the sixth postoperative month and the values were improved. In our study, the EMG recordings of all patients were significantly decreased in the sixth month after surgery, along with the post-op measurements of the M. transversus nasalis and M. dilator muscles, which were significantly lower in the nasal obstruction group compared to the group without nasal obstruction. This discrepancy between studies may be due to differences in surgical experience, types and localization of electrodes used in EMG technique, the temperature of the muscles, the means of the motor unit potential activation, the number of the fibers in the muscle and the concentration of the muscle fibers.

Since open rhinoplasty operations have many advantages over nasal muscles such as having a wide angle of view, easier preservation of related structures and no blinding of nasal dorsum elevation compared to closed rhinoplasty operations [13], open technique rhinoplasty operation was preferred in all patients in our study. However, all patients had a decrease in EMG amplitudes at the 6th month after surgery. One limitation of our study is that the observation period is as short as 6 months. As in the study of Batioglu-Karaaltin et al. [14], amplitudes could be increased during longer follow-ups, due to the fact that insufficient muscle contraction, positional changes in muscles and soft tissues, and edema all may cause lower EMG amplitudes during the postoperative period. All these factors are likely to improve in the future, allowing muscle amplitudes to increase [13].

Limitations

The main limitation of the present study was lack of objective evaluation and comparison of patients' nasal breathing with rhinomanometric examination before and after surgery. Short follow-up period and number of patients were the other limitations.

In future studies, we plan to increase the number of patients, investigate patients who underwent closed rhinoplasty, and to add rhinomanometric examination to the research protocol.

Conclusion

Even if an open technique rhinoplasty operation is performed, as a result of the damage to SMAS and nasal muscles during incision, elevation and other rhinoplasty stages, a decrease in the amplitudes of M. procerus, M. transversus nasalis and M. dilator which are the major muscles of the nasal function and the aesthetic appearance, may be observed. Furthermore, the damage of M. transversus nasalis and M. dilator during rhinoplasty may play an important role in post-op nasal obstruction. Preservation of these muscles and SMAS during operation may reduce the incidence of post-op nasal obstruction.

Acknowledgments

The authors would like to thank Bahat Medical Center Group's Hospitals chief physician Dr. Hamza Bahat, Istanbul Yeni Yüzyıl University and İstanbul University-Department of ENT.

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