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Anatomic and functional changes after myotomy with or without mandibular anguloplasty in masseter hypertrophy patients: A prospective study☆

Sujata Mohanty*, Priyadarshan Kumar, Ujjwal Gulati, Jitender Dabas, Sanchaita Kohli, Zainab Choudhary

Department of Oral and Maxillofacial Surgery, Maulana Azad Institute of Dental Sciences, MAMC Complex, Bahadur Shah Zafar Marg, New Delhi, 110002, India

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ABSTRACT

Objective: The current study aims to evaluate the anatomic and functional outcome in patients with masseter hypertrophy following surgical debulking of the masseter.

Methods: 18 patients (28 sites) of masseter hypertrophy underwent surgical muscle debulking with / without osseous recontouring. Post-operative assessment was done by measuring change in: a) muscle thickness using ultrasonography, b) electrical activity of the muscle using electromyography (EMG) and c) maximum bite forces generated 1 year following surgery. Visual Analogue Scale (VAS; 1–10) was used to evaluate the patients' aesthetic satisfaction.

Results: An average reduction in muscle thickness at rest and clench by 6.35 and 5.25 mm, respectively was seen 12 months after surgery. Mean bite force and clench EMG showed a statistically significant decrease 1 year post-operatively ($p = 0.001$ and $p = 0.0001$ respectively). The average mouth opening increased significantly by 8 mm ($p < 0.05$) and a mean aesthetic satisfaction VAS score of 8.1 was reported by patients after 1 year.

Conclusion: Surgical debulking is a reliable treatment modality for masseter hypertrophy providing good aesthetic and functional outcomes.

1. Introduction

Benign masseter muscle hypertrophy, first described in 1880 as "an ill-defined tumour mass" occurring in the masseter muscle of a twelve-year old girl child [1], is generally characterised by a unilateral or bilateral enlargement of masseter muscle volume. All but a few patients report with the complaint of either facial asymmetry in unilateral hypertrophy or a broad/flaring face in bilateral cases [2,3]. Clinical examination and radiographs viz. orthopantomogram (OPG), postero-anterior view skull (PA view) and ultrasonography (USG) are the mainstay of diagnosis. An array of management strategies has been tried ranging from pharmacological therapy to surgical excision. However, botulinum toxin Type A (BT-A) and radiofrequency coagulation (RFC) are advised for mild cases and surgical excision for moderate to severe cases [4–7]. Following surgical correction, the changes in the electrical activity of the hypertrophied muscle and bite forces that take place have been insufficiently reported in literature. The current study aims to evaluate the anatomic and functional changes following surgical debulking of the hypertrophied muscle with or without a concurrent anguloplasty.

2. Materials and methods

A prospective study including unilateral or bilateral cases of masseter hypertrophy (10 bilateral cases) was designed, where the diagnosis was made using patient history and clinical and imaging findings (Fig. 1: A and B). All patients reporting with a complaint of a painless, soft facial swelling over the mandibular angle region and giving a suggestive history (longstanding decayed or missing teeth, abnormal chewing habits) underwent local examination of the masseter region,

☆ AsianAOMS: Asian Association of Oral and Maxillofacial Surgeons; ASOMP: Asian Society of Oral and Maxillofacial Pathology; JSOP: Japanese Society of Oral Pathology; JSOMS: Japanese Society of Oral and Maxillofacial Surgeons; JSOM: Japanese Society of Oral Medicine; JAMI: Japanese Academy of Maxillofacial Implants.

* Corresponding author.
E-mail addresses: drsm28@gmail.com (S. Mohanty), doctorpd@rediffmail.com (P. Kumar), drujjwalgulati@gmail.com (U. Gulati), jits.osmaids@gmail.com (J. Dabas), sanchaita.kohli@gmail.com (S. Kohli), zainabgauri@yahoo.co.in (Z. Choudhary).

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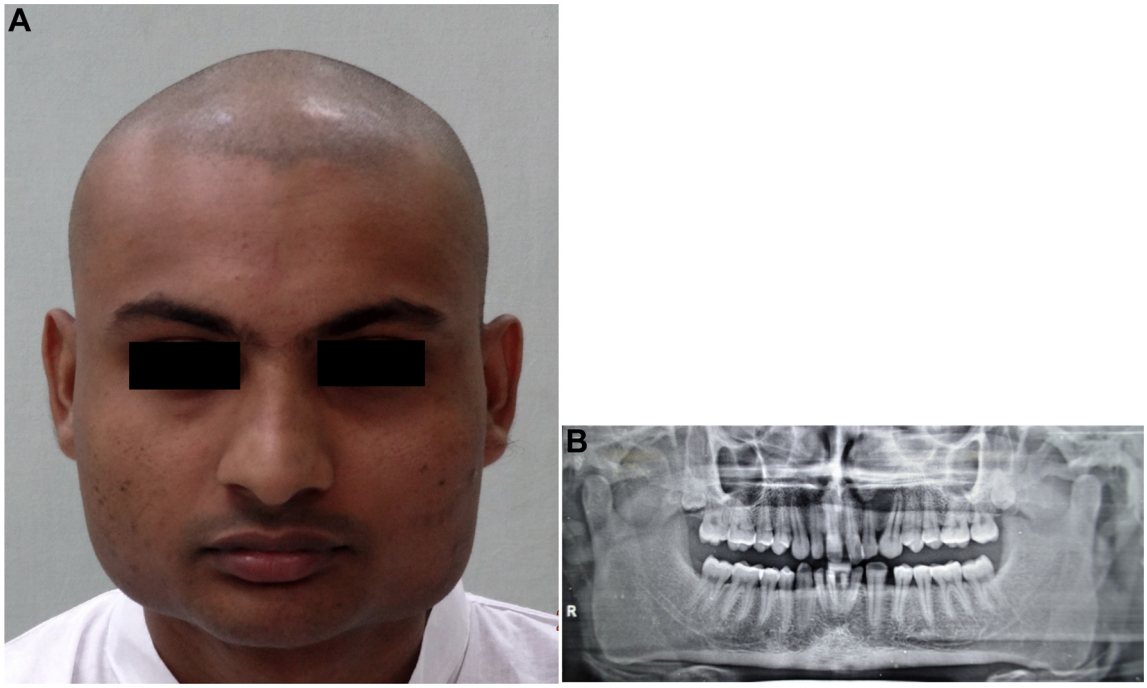

Fig. 1. Pre-operative clinical and radiographic findings of a patient with bilateral masseter hypertrophy.
A. Frontal profile at rest showing square facies with swelling over bilateral mandibular angle region.
B. Pre-operative OPG showing bony hypertrophy in bilateral mandibular angle region.

where palpation of the masseter at rest and during clench was done to assess for an increase in muscle thickness and differentiate it from any other discrete lesion in the area. Additionally, local examination of the dentition and occlusion was done to look for possible factors causing muscle hypertrophy. The masseter was then further evaluated using ultrasonography, where a generalised increased in muscle thickness at rest and during clench confirmed the diagnosis of masseter hypertrophy. All existing factors that could potentially lead to masseter hypertrophy were then alleviated, i.e., all carious teeth were appropriately restored, missing teeth were replaced by fixed prosthesis and parafunctional habits were corrected. After all such factors were eliminated, the esthetic correction was planned, where the patients were provided with the option of either undergoing treatment with botulinum toxin injections or surgical muscle debulking. All patients who opted for surgical debulking were then included in the current study. Ethical clearance for the study was obtained from the institution review board and a written informed consent was obtained from all patients. The following inclusion and exclusion criteria were used for recruitment of patients:

2.1. Inclusion criteria

1 Unilateral or bilateral masseter hypertrophy requiring surgical intervention.
2 Age range 18–45 years.
3 Healthy dentition.
4 No previous surgical treatment received.

2.2. Exclusion criteria

1 Temporomandibular disorders/myofunctional pain dysfunction syndrome.
2 Uncontrolled systemic diseases.
3 Pathology/lesion involving the masseter.

2.3. Surgical technique

The selected patients underwent surgical debulking of the hypertrophied masseter muscle with / without mandibular angle recontouring under general anaesthesia administered via fiberoptic nasoendotracheal intubation. The surgical site was aseptically prepared and 2% lignocaine with 1:80,000 adrenaline was infiltrated at the site of the incision to aid in haemostasis. The approach for the myotomy depended on the pre-operative decision to excise only muscle or both muscle and angular spur. Intra-oral approach was used for the former scenario and extra-oral for the latter (Fig. 2). The amount of muscle excision to be done was grossly estimated from the muscle thickness recorded on the pre-operative USG, keeping in mind the normal masseter thickness, using which a muscle thickness excess value could be projected and the same was used to guide the intra-operative volume of muscle excision. The osseous recontouring was similarly planned by making a prediction tracing on the patient OPG for an acceptable looking mandibular angle and then calculating the bony excess by comparing with the master tracing of the same OPG.

2.3.1. Extra-oral approach

Through a modified submandibular incision around the angle of mandible, the central two-third portion of the masseter muscle insertion was freed from inferior border of the mandible. With the masseter and its periosteal attachment retracted, the resection of the hypertrophied muscle was carried out from its medial surface. When the muscle was reduced to its normal thickness, the medial pterygoid was detached from the medial side of mandible to expose the underlying localized bony enlargement, which was removed and recontoured using hand and rotary instruments. The reduced muscle belly was then sutured back to the free margin of the pterygomasseteric sling and the incision was closed primarily in layers.

2.3.2. Intra-oral approach

An incision was made in the mucosa, 5 mm lateral to the ipsilateral mandibular buccal vestibule, extending from the first molar to half the height of the anterior border of the ascending ramus. The buccinator

Fig. 2. Intra-operative picture of surgical debulking of the masseter with mandibular angloplasty showing the resected muscle mass and bone.

muscle was transected to expose the anterior border of the ramus followed by dissection of the anterior border of the masseter. When the lateral surface of the masseter was visible, the retractor and instruments were removed, and the dissection was performed with index finger of the surgeon. The dissection of the lateral surface was performed in the masseteric fascia plane, with splitting of the fascia from the superficial musculoaponeurotic system. After the lateral dissection of the masseter, the medial surface of the muscle was also detached from the ramus with a periosteal elevator. With the entire muscle exposed, from the angle up to the zygomatic arch, the transverse dimension of the muscle could be perceived and split in a more desirable manner. The debulking of the muscle was done from the lateral surface. The volume of muscle to be resected varied, depending on the severity of the hypertrophy and the associated deformity. After debulking the muscle, haemostasis was achieved, and primary closure of the incision was done.

2.4. Post-operative care

In the immediate post-operative period, an extra-oral pressure dressing was maintained for at least 24–48 hours over the surgical site to minimize the post-operative swelling. Intravenous antibiotics and analgesics were prescribed for an average of 5 days. Passive mouth opening exercises were advised from the second post-operative day and active physiotherapy one week post-operatively to allow the muscle to adapt physiologically as early as possible.

2.5. Post-operative assessment

Post-operative assessment was done with the help of clinical examination, measurement of EMG and bite force changes at the intervals of one, three and twelve months and ultrasonographic evaluation twelve months post-operatively. In addition, changes in the active mouth opening were also assessed, along with the patients' satisfaction of aesthetic outcome using Visual Analogue Scale (VAS), number of cases of marginal mandibular nerve paresis (MMNP) in cases of extra-oral surgical approach and other complications associated with the surgery. The patients were followed up for a period ranging from 12 to 70 months.

2.5.1. Clinical assessment

Clinical examination included inspection of the surgical wound, comparison of pre- and post-operative aesthetics, mouth opening at one, three and twelve-month intervals.

2.5.2. Anatomic parameters

1 Muscular thickness: The thickness of masseter (at rest and clench) was assessed using 10 MHz linear transducer with an accuracy of 0.1 mm with patient in a supine position. The site for relevant cross-section was kept at a level halfway between the zygomatic arch and the gonial angle, with the transducer directed perpendicular to the muscle fibres.

2.5.3. Functional parameters

1 EMG: EMG was done using Bio EMG III, Bio research Inc. USA. Patient was seated comfortably on a dental chair and electrodes were placed over maximum bulk of the masseter. EMG readings for the maximum amplitude of the masseter muscle were taken at rest and at maximum clench and recorded at four stages; pre- and post-operatively at 1, 3 and 12 months.
2 Bite force: With patient seated in a comfortable position, a pressure-sensitive film was placed between occlusal surfaces of the teeth and the patient was instructed to bite with maximal force in maximum intercuspation. This film was subjected to computer assisted scanning (NUPAI bite force scanning system, Japan), which calculated the magnitude of bite force in pounds, which was then converted to Newtons (N). Bite force of each patient was also recorded at four stages; pre-operatively and 1, 3 and 12 months post-operatively.

All data was collected and analysed by a single observer. The data obtained was analysed using the Wilcoxon signed-rank test. Statistical analysis was performed using IBM SPSS Statistics version 20.0 software (IBM Corp., Armonk, NY, USA). Data obtained for mouth opening was analysed using the paired t-test. The 5% probability level was considered as statistically significant, i.e. $p < 0.05$.

3. Results

The present study analysed 28 sites in 18 patients (10 bilateral cases) of masseter hypertrophy for anatomic and functional changes following myotomy. The male:female ratio was 1:1 both with respect to the number of patients and number of sites affected. Average age of patients undergoing surgical debulking was 24.8 years (range = 18–32 years). All patients reported with the chief complaint of compromised aesthetics and gradual decrease in mouth opening, except one who also had pain in the hypertrophied muscle. 21 out of the 28 sites, all 10 patients of bilateral hypertrophy and 2 out of the 8 unilateral cases had an associated angular spur and therefore, required angular re-contouring (Table 1).

3.1. Anatomic parameters

1 Muscle thickness: Median pre-operative and 1-year post-operative muscle thickness at rest was found to be 13.5 mm and 7.15 mm

Table 1
Patient demographics, site, complaint, surgical extent and approach.

S. No.	Age/Sex	Chief Complaint	Extent and Approach	Unilateral/ Bilateral
1.	29/M	Cosmetic plus pain	Muscle + bone, Extraoral	Bilateral
2.	26/F	Cosmetic	Muscle + bone, Extraoral	Bilateral
3.	31/M	Cosmetic	Muscle + bone, Extraoral	Bilateral
4.	29/F	Cosmetic	Muscle + bone, Extraoral	Bilateral
5.	23/F	Cosmetic	Extraoral on one side for both muscle and bone and intraoral on other side for muscle only	Bilateral
6.	29/F	Cosmetic	Muscle + bone, Extraoral	Bilateral
7.	32/M	Cosmetic	Muscle + bone, Extraoral	Bilateral
8.	23/M	Cosmetic	Muscle, Intraoral	Unilateral
9.	27/F	Cosmetic	Muscle + bone, Extraoral	Unilateral
10.	23/F	Cosmetic	Muscle, Intraoral	Unilateral
11.	23/F	Cosmetic	Muscle, Intraoral	Unilateral
12.	18/M	Cosmetic	Muscle + bone, Extraoral	Bilateral
13.	24/M	Cosmetic	Muscle, Intraoral	Unilateral
14.	22/F	Cosmetic	Muscle + bone, Extraoral	Unilateral
15.	19/M	Cosmetic	Muscle, Intraoral	Unilateral
16.	24/M	Cosmetic	Muscle + bone, Extraoral	Bilateral
17.	20/F	Cosmetic	Muscle + bone, Extraoral	Bilateral
18.	25/M	Cosmetic	Muscle, Intraoral	Unilateral

Table 2
Pre-operative and Post-operative Comparison of Muscle Thickness, EMG, Bite Force and Mouth Opening Values.

Parameter	Patient visit	Minimum	Maximum	Range	Median
RESTING MUSCLE THICKNESS (mm)	Pre-operative	8.3	14.8	6.5	13.5
	After 1 year	5	8	3	7.15
CLENCH MUSCLE THICKNESS (mm)	Pre-operative	12.8	19.1	6.3	17.5
	After 1 year	10.1	13.8	3.7	12.25
RESTING E.M.G. (microvolts)	Pre-operative	0.57	1.71	1.14	0.96
	After 1 month	0.41	1.28	0.87	0.80
	After 3 months	0.47	1.19	0.72	0.78
	After 12 months	0.51	1.28	0.77	0.89
CLENCH E.M.G. (microvolts)	Pre-operative	102	580.50	478.5	281.4
	After 1 month	43.20	253.30	210.1	154.4
	After 3 months	33.70	269.50	235.8	168.75
	After 12 months	26.40	283.70	257.3	210.6
BITE FORCE (Newton)	Pre-operative	582	1303	721	988.5
	After 1 month	258	710	452	493
	After 3 months	433	740	307	616.5
	After 12 months	450	780	330	680
MOUTH OPENING (mm)	Patient Visit	Mean	S.D.		
	Pre-operative	30.32	1.97		
	After 12 months	38.32	1.38		
	Difference	8.00	1.68		

respectively (Table 2). The decrease in muscle thickness (6.35 mm) was found to be statistically significant ($p = 0.0001$). Similarly, the muscle thickness in clench decreased from a median of 17.5 mm pre-operatively to 12.25 mm 1 year post-operatively with a difference of 5.25 mm. This decrease was also found to be statistically significant with ($p = 0.0001$).

2 Patients' satisfaction of aesthetic outcome: The readings on VAS after 1 year were in range of 6–10 with a mean of 8.07 (Fig. 3: A and B).

3.2. Functional parameters

1 EMG: The median pre-operative resting EMG of 0.96 μV gradually and significantly decreased to a median of 0.89 μV over 1 year ($p = 0.0001$), while the median clench EMG decreased significantly from 281.4 to 210.6 μV ($p = 0.0001$) (Table 2).

2 Bite force analysis: The median pre-operative maximum bite force (988.5 N) significantly decreased to a 1-year post-operative median of 680 N ($p = 0.0001$) (Table 2).

3.2.1. Active mouth opening

A mean increase of 8 ± 1.68 mm in mouth opening was seen from a pre-operative mean value of 30.32 ± 1.97 mm to the post-operative mean value of 38.32 ± 1.38 mm (Table 2). This difference obtained was found to be statistically significant with a p value of 2.59^{e-13}.

3.2.2. Complications of surgical debulking

A single patient developed MMNP which recovered gradually over a period of 16 weeks. A sialocoele developed in one patient which was managed conservatively.

4. Discussion

Several theories have been proposed to explain the aetiology of masseter hypertrophy ranging from its description as a 'work hypertrophy' due to excessive grinding/chewing [8,9] or an inability to chew from other side due to dental diseases like caries, periodontal problems or missing teeth [10], to masseter fatigue and lack of uniform enlargement of the muscle hold [2]. In all our patients, we could elicit a history of abnormal chewing habits viz. bruxism, excessive gum chewing and/or supari/gutka and were able to associate them with the condition.

Diagnosis of masseter hypertrophy is mainly based upon clinical examination, with imaging largely being an adjunct. Inspection at rest may or may not reveal additional mass in masseteric region, depending upon the degree of hypertrophy. However, clenching commonly leads to formation of a tumour like mass on lateral surface of the masseter. Palpation, at rest reveals a soft, non-tender and ill-defined mass along the direction of muscle fibres. Upon clenching, this mass becomes an inherent part of contracted masseter [2,3]. A bony projection may be felt at mandibular angle region flaring laterally like 'an ear'. This spur can be easily noticed on PA view. OPG also shows this spur as an over-inflated anatomical angle region. This "extra bony spur" along with muscle mass gives a swollen cheek appearance and additional prominence to mandibular angles; thus, the complaint of broad face/asymmetry by the patients. These features act against the natural feminine facial contour lines. In our cohort of patients, a bony enlargement was witnessed in 75% of sites (n = 21), requiring an additional angular contouring to normalise the aesthetics.

Of late, USG has evolved as an additional investigation. Raadsheer et al in 1996 compared USG and magnetic resonance imaging (MRI) to estimate the thickness of masseter muscle and found no statistical difference between the two techniques [11]. Rather, USG has an advantage of being more economical and hence may be used more frequently. It is also psychologically more comfortable for patients. We diagnosed patients using clinical examination and radiographs (OPG and PA skull view). Additionally, USG was used to compare the pre-operative and post-operative muscle thickness. Kiliaridis in 1991 used USG and reported a resting muscle thickness of 9.7 mm in males and 8.7 mm in females [12]. In our study, the median pre-operative and 1-year post-operative muscle thickness at rest was found to be 13.5 mm and 7.15 mm respectively, while the muscle thickness at clench was 17.5 mm and 12.25 mm, respectively (Table 2). A statistically significant reduction in muscle thickness both at rest and clench implies a favourable anatomic outcome with surgical debulking in masseter hypertrophy.

Among the functional parameters, bite forces have been measured by different techniques in human subjects [13–15]. Variability in technique and properties and positioning of pressure measurement device has led to variable values in the literature. We used a pressure-sensitive, paper thin sensor and its deformation was analysed using computerised software to estimate the bite force generated. Average

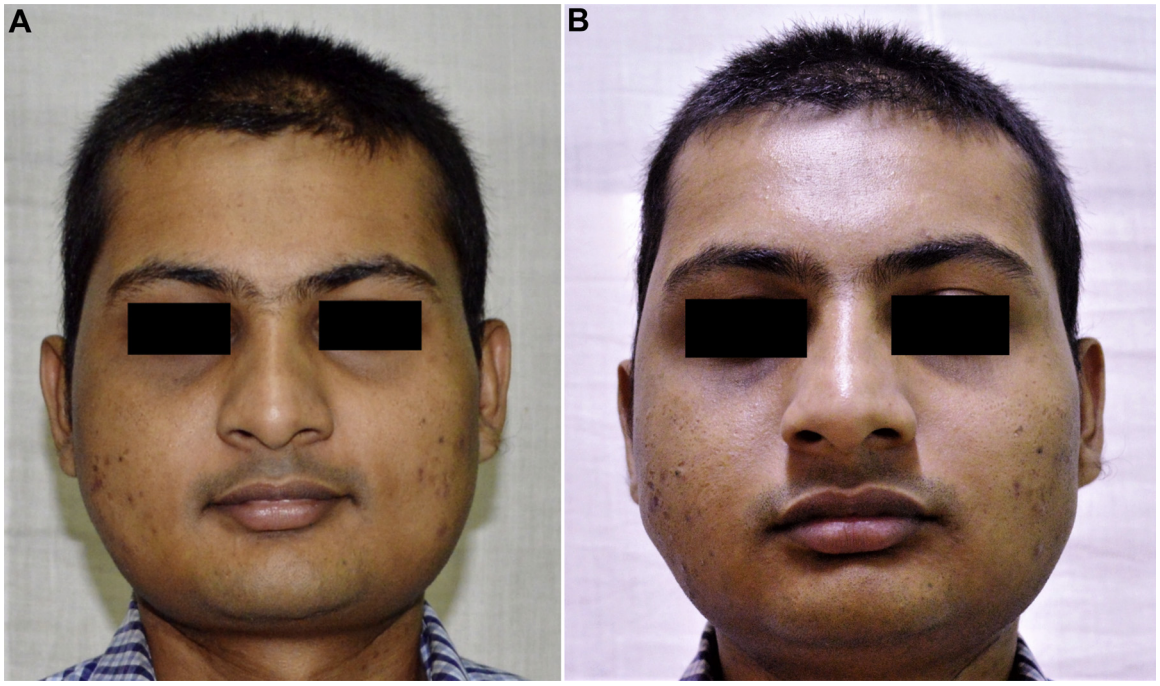

Fig. 3. One-year post-operative frontal profile of the patient at rest (A) and during clench (B).

bite force in healthy individuals has been found to be in a range of 500–700 N. In our study, the observed median pre-operative maximum bite force of 988.5 N was well above the normal value. However, this significantly decreased over the year to a median of 680 N, a value well within the range of normal bite force (Table 2).

Changes in the resting as well as clench EMG values were found to be statistically significant in this study ($p < 0.05$), implying that muscular hypertrophy elevates the EMG significantly and surgical debulking restores the value to near normal, as evidenced by the observed values (Table 2).

The assessment of bite force and EMG was done at four intervals for all patients: at the pre-operative visit and at the 1-month, 3-month and 6-month post-operative visits. It was observed that following surgery, there was a dramatic initial decrease in the bite force and EMG values. For instance, the median bite force value decreased from a pre-operative value of 988.5 N to 493 N, as measured at the 1-month post-operative visit (50.1% reduction). However, the values recorded at the subsequent visits were seen to gradually increase to 433 N (3 months post-operative) and then to 450 N 1 year following the surgery, showing a 37.9% increase from the reading seen at 1 month. The EMG recordings showed a similar trend (Table 2). The authors believe that the initial stark decrease in values may be ascribed to a loss of the tendinous attachment of the muscle from the underlying bone and its partial denervation during excision, resulting in temporary functional impairment. With due course of time, however, neuromuscular adaptation takes place and the muscle regains its structure, physiology, surface area of attachment and the strength of contraction drifts back to normal, resulting in a gradual increase in bite force and EMG values over time.

Another important observation was a significant increase in the mean mouth opening of the patients ($p < 0.05$). This increase observed may be due to surgical debulking of the muscle or reattachment of muscle fibres more superiorly after trimming the angular spur or reorientation of contraction vector after excision of flared spur. Favourable outcomes were thus achieved in terms of normal electrical activity and bite forces, along with an adequate mouth opening following surgical correction (Table 2). However, the main initial complaint of our patients was an unaesthetic appearance, so we documented the patients' satisfaction with the final aesthetic outcome using a Visual Analogue Scale (VAS), achieving a mean VAS score of 8.07, suggesting a good aesthetic result. Even though the amount of muscle and bony excision to be performed was planned pre-operatively by calculating the excess using pre-operative USG and OPG, the intra-operative execution of a precise excision is rarely feasible, and both muscle excision and bone contouring are usually subjective decisions which largely depend on surgical expertise. Obtaining a good VAS score, therefore, reassured the authors of the accuracy of the surgery.

Myotomy of the masseter can be performed intra-orally or extra-orally. Extra-oral approach provides good access to the surgical site, but there is always a chance of MMNP and an evident scar. In 1959, Ginestet et al addressed this issue by introducing and advocating the use of intra-oral approach for the same [16]. This approach avoids a scar and nerve damage but is more technique sensitive and the surgeon may struggle to resect larger amounts of muscle mass and the angular spur in a symmetric fashion. Therefore, an extra-oral approach is preferred in cases of anticipated large resections, especially a combination of muscle mass and angular spurs. We opted for an extra-oral approach in all cases where a myotomy with angular recontouring was required and intra-oral approach where sole reduction of muscle mass was needed. We encountered only a single case of transient MMNP in one patient with the extra-oral approach. A medial muscle excision is generally preferable to a lateral one as it is believed that it minimises the risk of marginal mandibular nerve injury. In the current study, a medial myotomy was done in all cases approach extra-orally because in these cases, the muscle was detached from the lateral ramus surface for osseous recontouring and the medial aspect of the muscle was readily accessible for excision. However, the same was not true when the muscle was approached intra-orally, and thus, a lateral myotomy was done for such cases.

The authors used surgery as a modality for treatment of masseter hypertrophy largely due to the unavailability of funds to procure botulinum toxin at their centre and also in pursuit of a relatively longer lasting result. The major drawbacks of this study were a small sample size and lack of a definitive criterion to analyse the aesthetic change. Further studies are recommended to compare these outcomes with those achieved following treatment with botulinum toxin.

5. Conclusion

Based on the current study, it may be concluded that surgical debulking of hypertrophied masseter is a reliable and predictable treatment in the hands of an experienced surgeon. The surgical correction is beneficial aesthetically and also leads to improvement in functional parameters. As with any surgical procedure, it is not devoid of risks and complications and therefore, the surgical approach must be appropriately selected.

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Conflicts of interest

None.

Ethical clearance

Obtained by the Ethical Committee of the institution.

Informed consent

All patients provided written informed consent for the study.

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