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Original Article

Impact of Sagittal Split Osteotomy Combined with Medpor® Porous Polyethylene Implant on Masticatory Reflex

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ABSTRACT

This study aimed to evaluate whether the use of alloplastic implants in the mandibular body and angle as an adjunct to orthognathic surgery affects the jaw reflex. 2 patients with severe mandibular asymmetry underwent sagittal split osteotomy combined with Medpor porous polyethylene implants. To examine changes in reflexes, surface electromyographic data were collected from the masseter muscle at multiple time points. The latencies and durations of the silent period were measured. In both patients, no masseter inhibitory reflex response was observed on the Medpor-augmented side during the first month post-surgery. Although the masticatory inhibitory reflex latencies, durations, and patterns were similar between the left and right sides for both patients, no silent period response was recorded on the side with the porous polyethylene implant by the sixth month after surgery. Consequently, the use of porous polyethylene implants may reduce masticatory reflex activity. While these implants appear to be clinically safe, careful evaluation of indications, risks, and potential outcomes is essential before their application.

Keywords: Masseter inhibitory reflex, Medpor, Sagittal split osteotomy, Porous polyethylene.

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Introduction

Many individuals with facial asymmetry experience unilateral hypoplasia of the mandible that significantly affects their aesthetic appearance. Alterations in the position of the chin, gonial angles, alignment of lip commissures, and the contours of the mandibular body can contribute to this asymmetry. Different techniques have been developed to address mild to moderate mandibular deficiencies [1]. For skeletal asymmetry of the mandible, methods such as distraction osteogenesis, costochondral grafts, conventional osteotomies, and alloplastic implants have been employed. Among these artificial graft materials, porous polyethylene (PPE) has been extensively utilized and is recommended as the optimal facial bone substitute due to its biocompatibility, ease of handling, stability, and reduced surgical time [2].

The Medpor® implant is a commercially available non-absorbable porous polyethylene device used for reconstructing various surgical defects. 2 studies have demonstrated its safety and effectiveness. A key benefit of porous materials is their ability to promote tissue growth into the pores, facilitating collagen deposition [3]. While augmentation with PPE is generally accepted as a beneficial supplementary approach in orthognathic surgery, the evaluation of results typically emphasizes postoperative complications, and histologic integration, or focuses on aesthetic or treatment outcomes [4-7].

To the best of our knowledge, no studies have confirmed the functional integration of sub-periosteal PPE augmentation with the surrounding soft tissue, nor demonstrated the effectiveness of PPE-based mandibular body and angle augmentation in addressing mild to moderate mandibular deficiencies. This report aims to present data on whether the application of alloplastic implants to the mandibular body and angle, as an occasional adjunct to orthognathic surgery, influences jaw reflexes. To investigate changes in these reflexes, sequential surface electromyographic (EMG) recordings were taken from the masseter muscle.

Materials and Methods

Subjects

The study included two patients who underwent sagittal split osteotomy with Medpor porous polyethylene implants to address severe mandibular asymmetry at our clinic between 2015 and 2019 (**Table 1**). The required amount of augmentation for each patient was determined through computed tomography analysis, and informed consent was obtained from all participants. The institutional review board approved this study, and all subjects voluntarily provided their consent to participate.

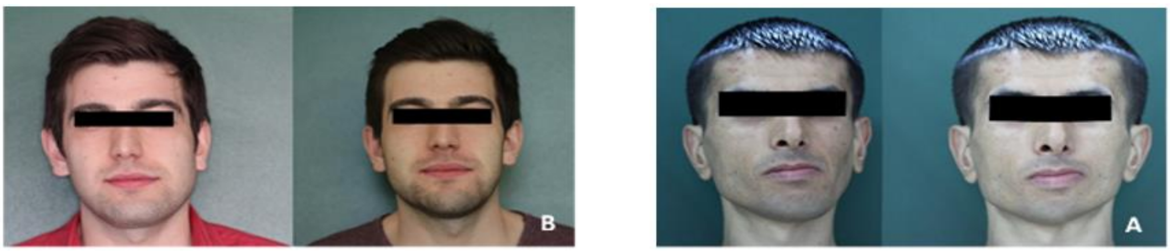
Both patients underwent computed tomography scans, and the digital imaging and communication in medicine (DICOM) data were processed using Mimics software version 12.0. The craniofacial skeleton was visualized using a slice reconstruction interval of 0.5 millimeters in a 3D display to assess the mandible. The mandibular contour was reconstructed by mirroring the normal contralateral side, and the Medpor implants were visualized to ensure accurate placement aimed at achieving a symmetrical mandibular contour.

Surgical Method

The surgical procedures were carried out under general anesthesia with nasotracheal intubation. Through an intraoral incision, full exposure of the outer cortex of the ramus, mandibular body area, and the lower edge of the mandible was achieved. Sagittal split ramus osteotomy (SSRO) was initially performed to address the malocclusion. The prefabricated Medpor implants were then shaped according to a surgical template. The implants were immersed in 90 degrees Celsius normal saline and molded to align with the outer cortex of the ramus and the mandibular body. After the implants were cooled, internal fixation was secured with titanium screws. Postoperative care included standard infection control measures and supportive therapy. The surgery resulted in an improved level of satisfaction, with enhanced symmetry based on quantitative measurements (**Figure 1**).

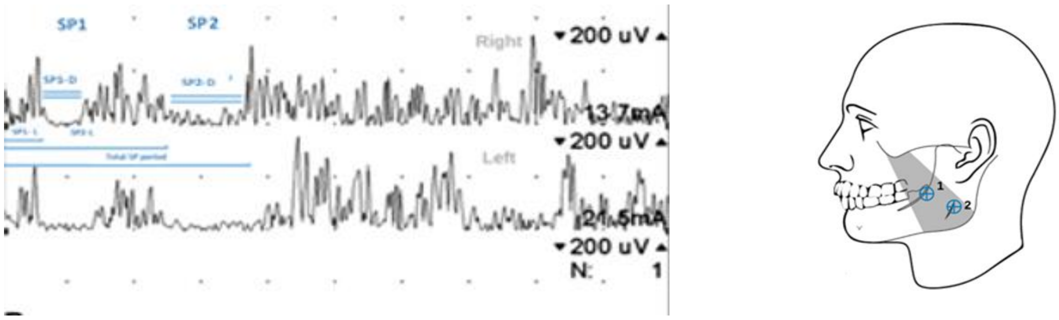
Masseter Inhibition Reflex

Each participant was instructed to clench their teeth with maximum force. Electrical stimuli were applied to the mental nerve, and electromyographic (EMG) signals were captured using surface electrodes placed on both masseter muscles (**Figure 2a**). The intensity required to reliably trigger the supraorbital blink reflex (SBR) was used to determine the threshold. The mental nerve was stimulated transcutaneously over the mental foramen with 2 different intensities: 5 times the SBR threshold and 8 times the SBR threshold. Each participant performed 5 trials on each side with 10-second rest intervals between them. Electrophysiological recordings were taken at three time points: T1 (pre-surgery), T2 (one-month post-surgery), and T3 (six months post-surgery). The signals were averaged to provide baseline EMG activity, and the latencies and durations of the silent periods (SP1 and SP2) were assessed (**Figure 2b**).



b) a)

Figure 1. a) patient I, b) patient II; preoperative photographs demonstrating a poorly defined left gonial angle on patient I and right gonial angle on patient II; postoperative photographs after the BSSO + mandibular implant resulting in bold symmetrical gonial contour.



b) a)

Figure 2. Masseter inhibition reflex recordings and assessments; a) EMG recordings were carried out using surface electrodes; the active electrode was positioned over the lower third of the muscle belly (1), while the reference electrode was placed approximately two cm above the angle of the mandible (2); b) after five reflex trials were recorded on one side, with varied excitation intensities during the masseter inhibitory recordings, the data were averaged through rectification. The display sensitivity was set to 200 µV per division; in the EMG traces, the initial silent period observed was labeled SP1, while the subsequent suppression was designated as SP2; the latency of the silent period was determined as the time when EMG activity dropped by 80% during both periods (SP1-L, SP2-L); the duration of the silent period was defined as the interval when the EMG amplitude was suppressed and increased by 80%, marked as SP1-D and SP2-D. Both SP1 and SP2 latencies and durations were measured in milliseconds (ms).

Results and Discussion

For patient I, although silent periods (SPs) were present bilaterally with similar latencies and durations preoperatively, a single prolonged silent period, merging SP1 and SP2, was observed on the left side with a stimulus of x8 threshold. By the first postoperative month, the masseter inhibitory reflex (MIR) couldn't be elicited on the augmented left side with the x5 threshold, whereas a normal configuration, including both SP1 and SP2, was induced with the x8 threshold. On the right side, SP1 was not elicited, and the duration of SP2 decreased from preoperative measurements (T1) to the first postoperative month (T2). In the sixth postoperative month, the left side showed an absence of SP1 with the x5 threshold stimulus, but SP2 was still present. The duration of both the late silent period and the total silent period at the x8 threshold was longer compared to T2. On the right side, SP1 remained absent, and the duration of SP2 was further shortened (**Table 1**).

Table 1. Patient details

Patient no.	Age (years)/sex	Cause	Type of surgery
I	32/M	Development	Left-sided augmentation with BSSO
II	26/M	Development	Right-sided augmentation with BSSO

In patient II, preoperative measurements showed that SP1 and SP2 were shorter in duration with the x5 threshold on both sides and with the x8 threshold on the right side. By the first postoperative month, SP1 couldn't be elicited on either side, and SP2 was not triggered with the x5 threshold on the augmented right side. During the sixth-month assessment, SP1 remained inelicitable with the x5 threshold on the right side but was successfully evoked with the x8 threshold. The duration of SP2 and the total inhibitory period on the right side were shorter compared to the left side (**Table 2**).

Table 2. Findings of the MIR

	Patient	1			2		
		T1	T2	T3	T1	T2	T3
Left	SP1 x5 latency	13.8	-	-	8.2	-	13.6
	SP1 x5 duration	14	-	-	7.2	-	11.2
	SP2 x5 latency	45.2	-	50.4	54.2	46.2	65.4
	SP2 x5 duration	46.4	-	50.1	30.4	20.8	42.2
	SP total duration	**60.4**	**-**	**50.1**	**37.4**	**20.8**	**53.4**

	SP1 x8 latency	14.2	12.8	17	14.6	-	18.8
	SP1 x8 duration	-	13.2	10.8	8.8	-	12.8
	SP2 x8 latency	-	48	52.8	49.8	55.6	67.6
	SP2 x8 duration	-	50	58.2	55.8	54.2	64.2
	SP total duration	**85.6**	**63.2**	**69**	**64.6**	**54.2**	**77**
Right	SP1 x5 latency	14.2	-	-	12.8	-	-
	SP1 x5 duration	15.4	-	-	8.4	-	-
	SP2 x5 latency	43	48.2	51	55.4	-	64.2
	SP2 x5 duration	46.4	14.4	38.4	31.2	-	40.6
	SP total duration	**61.8**	**14.4**	**38.4**	**39.6**	**-**	**40.6**
	SP1 x8 latency	14	-	-	14.2	-	11.8
	SP1 x8 duration	16.2	-	-	6.2	-	12.6
	SP2 x8 latency	44.2	45.8	54.4	54.4	51.6	63.6
	SP2 x8 duration	44.4	31.2	25.8	32.4	48.4	38.8
	SP total duration	**60.6**	**31.2**	**25.8**	**38.6**	**48.4**	**61.4**

T1, preoperative; T2, postoperative 1st month; T3, postoperative 6th months (T3), MIR, masseter inhibitory reflex, SP1, early silent period; SP2, late silent period; x5, 5 times threshold; x8, 8 times threshold; (-) response was inelicited

Previous studies have highlighted the connection between surgical correction of the mandible and changes in the MIR pattern, with the most frequent abnormalities observed in the early postoperative phase being a complete or partial absence of the silent period [8]. In the present study, we observed that the use of PPE implants as an adjunct treatment for mandibular asymmetry resulted in the loss of the SP1 response on the augmented side during the later stages of the postoperative period.

The primary aim of this research was to examine the potential impact of PPE implants on the MIR. This reflex serves as a protective mechanism, preventing the jaws from making contact and causing damage to the teeth and surrounding structures [9]. Liu *et al.* [10], in their EMG analysis of jaw muscles in patients with temporomandibular dysfunction, found a positive correlation between muscle and joint pain and the duration of the silent period in the masseter muscle. In our study, the first patient showed a normal inhibitory reflex response on the right side at baseline, but no distinction was observed in the early and late reflex periods on the augmented side. In the second patient, although baseline MIR parameters were within the normal range, the reflex durations on the augmented side were shorter compared to the right side. These findings suggest that asymmetry may affect reflex responses.

Stimulation of the trigeminal nerve fibers triggers a suppression of voluntary contractions in the human masseter and temporalis muscles, a reflex known as the silent period or exteroceptive suppression [11]. In this study, the results indicated that in both patients, the MIR response on the Medpor-augmented side could not be elicited using the x5 threshold in the first month after surgery. By the sixth month, SP1 was still absent with the x5 threshold stimulus on the augmented sides in both patients, although other parameters showed gradual improvement. Despite extensive research on the silent period in human jaw-closing muscles, the exact physiological regulation of this reflex remains unclear. It has been hypothesized that the underlying mechanism may involve hyperactivity of the central nervous system and abnormal cortical or reticular activity, which could increase the excitability of trigeminal motor neurons through the modulation of multisynaptic reflexes [12, 13].

Early inhibition likely plays a role during normal chewing motions, while late inhibition may serve a protective function to prevent injury to the perioral tissues or oral mucosa [14]. In this study, although the postoperative MIR latencies, durations, and configurations were comparable between both sides in both patients, the SP1 response was not triggered following PPE implant placement in the sixth month after surgery. This suggests that one might not expect the same chewing pattern after PPE augmentation. Nevertheless, even though the pattern of masticatory reflex was altered, MIR responses were still observable in both patients during the later postoperative period. This may be attributed to the fact that the amplitudes of EMG signals are influenced by factors such as muscle potential propagation to the electrode, the amount of connective tissue and fat, and skin impedance [15]. Additionally, various receptors, including intraoral mucosal receptors, periodontal mechanoreceptors, and muscle spindle receptors, all contribute to the MIR response [16]. The early phase of MIR is an oligosynaptic reflex, while the later phase is polysynaptic, meaning that even a minimal signal transmission can trigger this reflex. In both patients, factors such as PPE implant placement, muscle injury, and potential damage to the inferior alveolar nerve might have contributed to the delayed initiation of the oligosynaptic early reflex. Furthermore, supranuclear control of this reflex in the brainstem may explain the shortening of SP2 and the prolongation of its latency [9, 17].

Santos *et al*. demonstrated that PPE implants promote bone healing through the incorporation of the material with surrounding tissues, with integration observed 145 days post-surgery [18]. Additionally, the complication rate following PPE implant augmentation was reported at 36.9%, with the primary reason for failure being the development of prominence, necessitating re-operation and/or removal [19]. Despite this, the low complication rate and tissue ingrowth seen in experimental studies support the use of PPE implants as a well-accepted option for craniofacial reconstructions [20]. However, to the best of our knowledge, no study has specifically addressed the impact of PPE use on chewing function in the mandible. Our findings suggest that PPE implants may hinder the restoration of muscle electrical activity, with structural muscle damage from surgery, and the PPE placement potentially causing a delayed recovery of this reflex. Clinicians should consider including the possibility of functional chewing impairment in patient consent forms. While these materials yield favorable outcomes for both surgeons and patients, the benefits must be evaluated on a case-by-case basis. Moreover, it is crucial to assess how the bone and surrounding structures recover histologically after PPE augmentation, and therefore, further studies investigating this effect are recommended.

Conclusion

In summary, porous polyethylene implants might impact masticatory reflex activity. While these implants appear to be clinically safe, their indications, potential benefits, and risks must be thoroughly assessed before use.

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Conflict of Interest: None

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Ethics Statement: The research adheres to the principles outlined in the Declaration of Helsinki (revised in Tokyo 2004) and received approval from the Institutional Review Board for Human Studies at the Dentistry Faculty of Istanbul University, Turkey (Study 2015/69).

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