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Original Research Article

Effect of hard and soft occlusal splints on EMG activity of inferior lateral pterygoid muscle in patients with mild to moderate occlusal wear - A randomized control trial

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Abstract

Introduction: Tooth wear is a complex phenomenon with multifactorial aetiology & high prevalence. Permissive splints help in muscle deprogramming and restoring the stability of TMJ. It is crucial to study the effects of splints on muscle activity, the optimal duration of wear of these splints to bring the desired effect, and the difference in the action of splints fabricated in different materials.

Objective: To compare the effect of hard and soft splints on EMG activity of Pterygoids in patients with moderate to severe tooth wear at different intervals.

Materials and Methods: Participants within the age range of 18–30 years having wear of teeth were allocated into group I HS (n=5) receiving hard splints and group II SS (n=5) receiving soft splints and a control group without splints (n=5). Electromyography (EMG) activity for inferior belly of lateral pterygoid muscle was recorded during postural rest position (PRP) and maximum voluntary clenching (MVC) at baseline (T0), 24 hours (T1) and at 8 weeks (T2) with and without splint. Nonparametric tests were used for within-group and intergroup comparisons, followed by post hoc analysis with Bonferroni correction.

Results: Baseline EMG activity was higher in soft splint experimental groups but the difference was nonsignificant ($p > 0.05$). At 24 hours, both the groups showed significantly lower ($p < 0.05$) EMG activity with the splint as compared to without the splint. Hard splints led to decreased muscle activity, while soft splints led to an increase at 8 weeks as compared to baseline EMG activity of controls, and the difference was nonsignificant. The intergroup comparison revealed insignificant differences at all-time intervals ($p > 0.05$).

Conclusion: Muscle activity varied with different materials of the splint and duration of use. Both splints helped in the adaptation of muscles to new vertical dimensions of occlusion at 8 weeks with lesser variation between with and without splint position.

Keywords: Lateral Pterygoid, EMG, Muscle, Inferior Belly, Splint

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1. Introduction

Temporomandibular disorders are common musculoskeletal conditions affecting the temporomandibular joint masticatory muscles, and associated structures, leading to pain, restricted mandibular movement, and joint sounds.[1] Among various subtypes, pain-related TMD has higher prevalence in young and middle-aged adults, especially females.[2,3] Diagnosis has advanced from the Research Diagnostic Criteria for TMD (RDC/TMD) to the more comprehensive Diagnostic Criteria for TMD (DC/TMD), yet challenges persist due to the multifactorial etiology and overlapping symptomatology.[4]

To the rescue surface electromyography is a widely used, non-invasive technique for assessing masticatory muscle activity, offering clinical insights into muscle function and coordination in TMD patients.[5] While Surface EMG provides a window into neuromuscular physiology, it may be influenced by factors such as skin impedance and electrode placement, especially when measuring deep muscles like the lateral pterygoid.[6,7] Therefore, Intramuscular EMG with fine needle is a better alternative when deep muscles are evaluated for muscle activity.[8]

The lateral pterygoid muscle, particularly its inferior head (ILP), plays a central role in mandibular movements such as jaw opening, protrusion, and stabilization during lateral excursions.[9] Electromyographic studies indicate that the ILP is predominantly active during mandibular opening and protrusive movements, whereas the superior head is

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engaged during clenching and closing phases.[10,11] Understanding the activity of the ILP is crucial, particularly in cases of occlusal wear where vertical dimension alteration is required.

Tooth wear, often associated with parafunctional habits like bruxism, results from engram mediated muscle adaptations to occlusal interferences where feedback loops from the teeth to the brain cause repetitive muscular responses to erase occlusal disharmonies.[12] Bruxism affects nearly 20% of the population, with up to 20% of bruxers showing clinical TMD signs.[13]

Occlusal splints are commonly used to deprogram hyperactive muscles and stabilize the TMJ. Hard stabilization splints offer a firm occlusal platform that facilitates neuromuscular relaxation, whereas soft splints may act more by distributing occlusal forces and altering proprioceptive input.[14] Previous studies have demonstrated a reduction in EMG activity in the anterior temporalis and masseter muscles with hard splint use, but the influence of soft splints remains variable.[15] Furthermore, there is a paucity of literature evaluating their effects on the ILP muscle specifically, despite its clinical relevance in establishing and maintaining vertical dimension.

Literature is still scanty to report the effect of hard and soft splints on EMG activity of inferior Lateral pterygoid muscle in patients with tooth wear, which is, however, relevant to study, especially when we need to alter the vertical dimension of the patients before definitive phase.

The purpose of this randomized controlled trial was to compare the effect of hard and soft splints on Inferior lateral pterygoid muscle activity in patients with mild to moderate wear measured at postural rest position (PRP) and maximum voluntary clenching (MVC), at 24 hrs and up to 8 weeks, with and without splint.

2. Materials and Methods

2.1. Trial design

This randomized controlled trial was begun after obtaining ethical clearance from the Institution Ethics Sub Committee (KIMS/IEC/A247/D/2025) and followed Consolidated Standards of Reporting Trials (CONSORT) guidelines. (**Figure 1**)

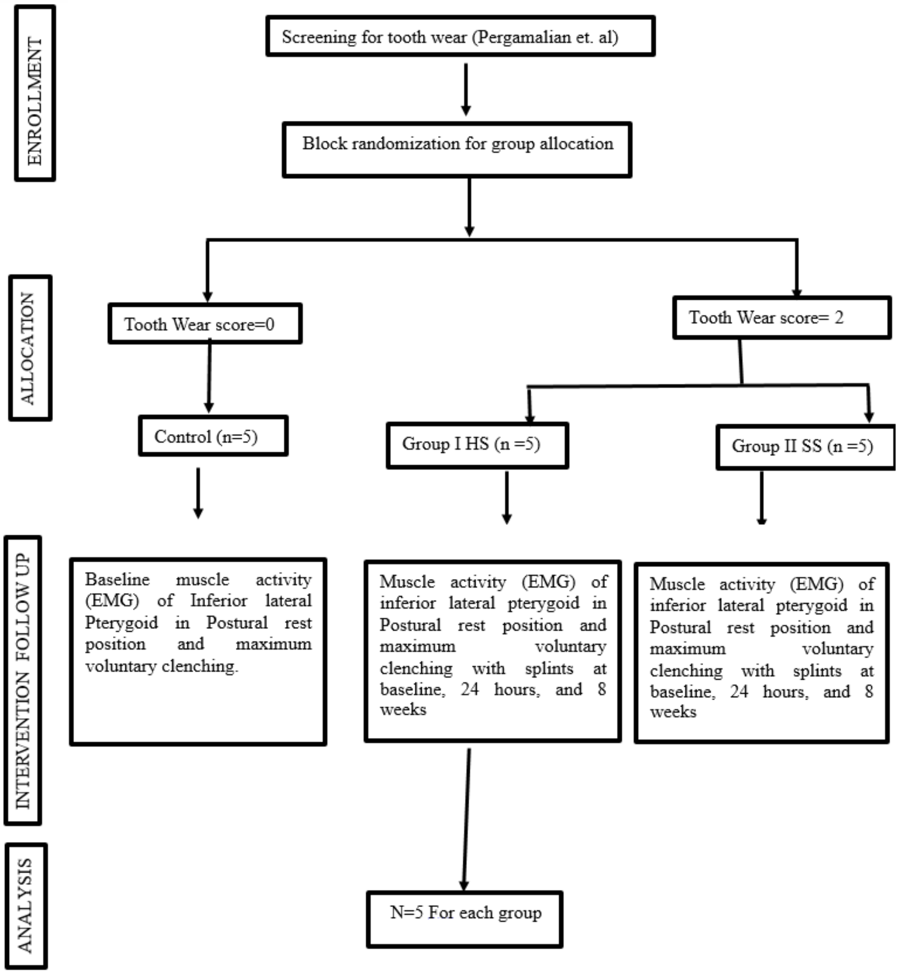

Figure 1: Flowchart as per CONSORT guidelines

2.2. Sample size estimation and randomization

The convenience sampling method was used to enroll a total of 15 participants. Each participant was allocated to one of the two experimental groups (n = 5): group IHS (hard splint–heat cure stabilizing splint) and group IISS (soft splint–thermo-vacuum formed soft polyvinyl splint) using computer-generated block randomization list, stratified by gender and severity of the wear. Five age and gender-matched controls following the same inclusion and exclusion criteria except for wear score (score 0 or 1) were selected to record their baseline EMG activity, but they did not receive any splint therapy.

2.3. Rationale for sampling method

Convenience sampling was employed to facilitate recruitment of eligible participants within the clinical setting, considering the time-bound nature of the study and the complexity of EMG recordings. This approach ensured feasibility while maintaining methodological rigor. To reduce potential bias, allocation to experimental groups was performed using a computer-generated block randomization list stratified by gender and severity of wear, with age- and gender-matched controls included to strengthen comparability.

2.4. Inclusion criteria

1. Patients within the age range of 20-30 years, irrespective of gender
2. Signs of occlusal wear (Score of 2 according to pergamalian et al)
3. 28 full complement of caries-free and periodontally healthy dentition
4. No h/o enameloplasty/crowns/inlays
5. Tooth wear observed with brux checker

2.5. Exclusion criteria

1. Patients diagnosed with bruxism/ TMD/ neuromuscular disorder
2. History of analgesics

2.6. Diagnostic evaluation and consent

Bruxism was evaluated using a non-instrumental approach given which included self-reported clenching and fatigue of jaw muscles with or without pain in TMJ. Patients were explained about bruxism or clenching and were asked to monitor their habits for the next 1–2 weeks. Repeat history was taken, and family members were also enquired about any relevant observations, like a grinding sound while sleeping. Clinically, the subjects were palpated for any clicking sound or muscle hypertrophy. All the eligible participants were explained in detail about the study plan, desired compliance with wearing splints, EMG study, and follow-up visits. written informed consent was obtained as per the Helsinki Declaration from those who agreed to get enrolled in the study.

2.7. Soft splint Fabrication

The soft occlusal splint was fabricated over the maxillary cast using a 3 mm thick soft polyvinyl sheet in a pressure molding device with a thermally controlled, infrared heater. Splint was adjusted to establish uniform contact of posterior teeth and light contact of anterior teeth in centric occlusion (**Figure 2**).

Figure 2: Soft splint in position

2.8. Hard splint fabrication

An anterior deprogrammer (Lucia jig) was used to guide the mandible in centric relation and to create a separation of approximately 1.5 mm in the distal most teeth then a centric relation record was made using alu wax. Then, maxillary and mandibular casts were mounted on a semi-adjustable articulator using a face-bow and centric relation (CR) record.

Hard splints were made in heat-cure acrylic resin on the maxillary cast using indirect-direct method. In centric occlusion, evenly distributed bilateral posterior contacts and light contacts of anterior teeth were developed. Anterior guidance was adjusted to develop posterior disocclusion during eccentric movements (**Figure 3**).

Figure 3: Hard splint in position

All splints were fabricated by one operator to control variation in appliance construction and were checked for seating and accuracy by an experienced supervisor. Participants were instructed to wear the splint all day and night except during eating and to report immediately if they felt any discomfort after wearing the splint. Individual compliance was checked regularly through phone calls.

2.9. Electromyography

A Neurologist and trained technician from the Neurology Department performed all the EMG recordings after explaining the procedure to the participants and seating them comfortably with unsupported heads. Eight-channel EMG was standardized with fixed calibration (Nicolet Biomedical, Madison, United States of America) (**Figure 4**).

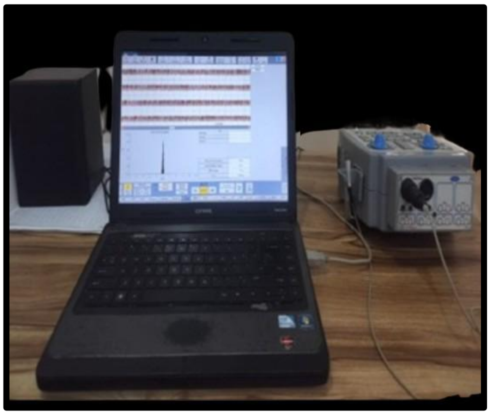

Figure 4: EMG machine with amplifier and visual display

Inferior Lateral Pterygoid muscle was palpated (**Figure 5**a), Topical anesthesia was sprayed on the muscle area and fine needle electrode was pierced into the muscle belly intra orally and secured in position (**Figure 5**b).

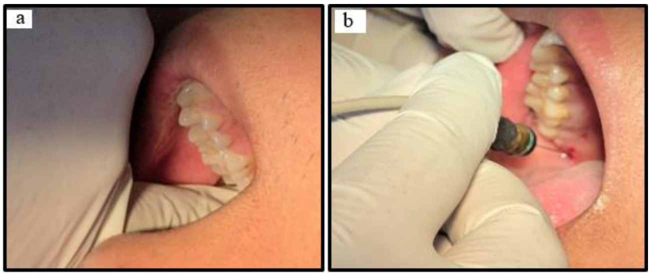

Figure 5: a: ILP being palpated; **b:** Fine needle inserted in ILP

A section of signals recording where the activities in all channels were steady over 5 seconds was taken. Quantitative values of amplified motor unit potentials in microvolts (μV) were measured from base to peak of the recorded graph using computer-assisted programming (Medelec Synergy) and the mean value of three readings was computed and tabulated in a Microsoft Excel sheet.

Recording of EMG activity was performed on each participant at three points, that is, pretreatment/baseline, after 24 hours (T1), and at 8 weeks (T2) after splint insertion. At each visit, EMG activity was recorded for two positions: at PRP and MVC, both with splint. For the volunteer group, EMG activity was recorded only at the time of their recruitment for the study at both muscle functioning positions. An individual who was blinded with study objectives and type of splint helped the participants to report their experience in speech/phonetics, pain/tenderness in TMJ, muscle tiredness, check biting, and headache subjectively on a self-designed Likert scale of 0–3 (0 = none, 1 = mild, 2 = moderate, and 3 = severe) after insertion of splints at follow-up visits.

2.10. Statistical analysis

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. Results on continuous measurement are presented as Mean±SD. Kurskal Wallis test is done to compare between the three groups. Comparison of rest and MIP values within a group is made using the Wilcoxon Signed rank test. No data for demographic details were presented as the mean and standard deviation or percentage, and muscle activity was presented in median (minimum–maximum) in microvolts. The normality of the data was checked using the Shapiro–Wilk test. Friedman test was used to determine intragroup change, followed by Wilcoxon signed-rank test with Bonferroni corrections for carrying out multiple comparisons. Intergroup comparison was carried out by Kruskal–Wallis test and Mann–Whitney U test. The confidence interval was set at 95%, and a p-value of <0.05 was considered statistically significant.

3. Results

3.1. Evaluation of EMG activity of inferior lateral pterygoid muscle

Electromyography (EMG) recording at PRP and MVC, with and without splint, showed no statistically significant difference ($p > 0.05$) in Inferior Lateral Pterygoid muscle activity on the right and left side. The difference in baseline (T0) EMG activity of inferior lateral pterygoid during PRP and MVC for both the experimental and controls were statistically nonsignificant, although the baseline muscle activity was higher in experimental groups than in controls ($p > 0.05$) Group I^{HS} showed a decrease in EMG activity at 24 hours and 8 weeks as compared to the baseline EMG of control group, but the difference was statistically nonsignificant ($p > 0.05$)Group II ^{SS} showed an increase in muscle activity at 8 weeks as compared to the baseline EMG of the control group in both positions, but the difference was statistically nonsignificant**.**

Table 1: Comparison between the three groups for parameters at rest

	Control		Hard splint		Soft splint		P value
	Mean	SD	Mean	SD	Mean	SD	
Day 0							
PtoP	39.80	12.13	375.40	123.28	201.40	88.04	0.003*

MRV	3.60	1.52	42.80	10.38	10.60	2.30	0.002*
RMSV	3.80	1.48	46.80	13.29	9.60	1.14	0.002*
Day 1							
PtoP	39.80	12.13	349.40	133.48	192.20	81.14	0.004*
MRV	3.60	1.52	41.00	10.20	9.80	1.92	0.002*
RMSV	3.80	1.48	45.20	13.08	9.20	1.64	0.007*
8 weeks							
PtoP	39.80	12.13	158.40	82.31	104.20	50.05	0.007*
MRV	3.60	1.52	25.80	11.05	6.00	1.58	0.004*
RMSV	3.80	1.48	25.20	15.19	5.60	1.52	0.004*

Kruskal Wallis test, *p<0.05, statistically significant
Inference: Significant intergroup differences were evident for all parameters (PtoP, MRV, RMSV) at all time points (p<0.05). Both HS and SS groups demonstrated higher values compared to controls initially, with a marked reduction at 8 weeks.

Table 2: Comparison between the three groups for parameters at MVC

	Control		Hard splint		Soft splint		P value
	Mean	SD	Mean	SD	Mean	SD	
Day 0							
PtoP	36.40	10.69	348.40	127.83	108.00	45.52	0.002*
MRV	2.20	1.10	42.60	10.60	8.20	1.92	0.002*
RMSV	2.60	1.14	46.80	16.16	7.80	1.64	0.002*
Day 1							
PtoP	36.40	10.69	327.00	118.78	103.00	44.03	0.002*
MRV	2.20	1.10	41.60	9.99	8.20	1.92	0.002*
RMSV	2.60	1.14	42.40	18.43	7.40	1.67	0.002*
8 weeks							
PtoP	36.40	10.69	147.40	113.37	52.40	20.76	0.006*
MRV	2.20	1.10	20.40	7.30	5.00	2.00	0.003*
RMSV	2.60	1.14	22.40	11.28	4.60	0.89	0.002*

Kruskal Wallis test, *p<0.05, statistically significant. Inference: Significant intergroup differences were observed (p<0.05). The HS group showed consistently higher values than the SS and control groups, with a pronounced decline in PtoP and MRV after 8 weeks.

Table 3: Comparison of parameters at MIP and rest within the hard and soft splint group.

	Rest		MIP		P value
	Mean	SD	Mean	SD	
Day 0					
PtoP	375.40	123.28	348.40	127.83	0.042*
MRV	42.80	10.38	42.60	10.60	1.00
RMSV	46.80	13.29	46.80	16.16	0.713
Day 1					
PtoP	349.40	133.48	327.00	118.78	0.080
MRV	41.00	10.20	41.60	9.99	0.786
RMSV	45.20	13.08	42.40	18.43	0.498
8 weeks					
PtoP	158.40	82.31	147.40	113.37	0.343
MRV	25.80	11.05	20.40	7.30	0.136
RMSV	25.20	15.19	22.40	11.28	0.498

Wilcoxon Signed Ranks Test, *p<0.05, statistically significant
Inference: Within the HS group, significant differences at baseline were noted for P to P (p=0.042) but not for MRV or RMSV. Over time, no significant changes were detected, suggesting stabilization of muscle activity by the intervention.

4. Discussion

Temporomandibular disorders (TMDs) are often associated with parafunctional habits, altered occlusion, and muscular dysfunctions, particularly involving the lateral pterygoid muscle. The inferior head of the lateral pterygoid plays a key role in mandibular translation and stabilization of the temporomandibular joint. [1] The lateral pterygoid muscle, particularly its inferior head (ILP), plays a vital role in mandibular movement's most notably in protrusion, depression, and coordination during lateral excursions. Unlike the masseter and temporalis, which primarily function during mandibular elevation, the ILP is uniquely active during forward translation and stabilization of the condyle within the articular eminence.[11,12] This makes it a muscle of special interest in patients with occlusal wear and temporomandibular disorders (TMDs) where joint loading patterns and vertical dimension may be altered.[1,3]

Inferior lateral pterygoid muscle was selected over the masseter or temporalis for EMG analysis because it is intricately involved in adaptive mandibular positioning. Unlike superficial elevator muscles, the ILP responds sensitively to occlusal interferences, parafunction, and changes in vertical dimension.[12] This specificity makes it a crucial, yet under-investigated, indicator of splint therapy outcomes in early occlusal rehabilitation.

Studies done by Goel et al. (2023) demonstrated that patients with tooth wear exhibit higher baseline EMG activity, with hard splints reducing and soft splints increasing muscle activity over time, particularly in the anterior temporalis. Both splints produced an immediate reduction at 24 hours, but by 8 weeks, muscle activity with and without splint approximated physiologic levels, reflecting neuromuscular adaptation to the altered vertical dimension. These results highlight the temporalis muscle's sensitivity to vertical changes and support an 8-week splint therapy phase to achieve functional stabilization before definitive rehabilitation.[16]

Occlusal interference can lead to hyperfunction of the ILP as the muscle attempts to maintain condylar positioning despite occlusal disharmony. This repetitive and compensatory muscle firing is often implicated in myogenous TMDs and may eventually lead to muscle fatigue, spasm, and altered mandibular kinematics.[3,13] Hence, monitoring ILP activity offers a direct evaluation of muscle response to occlusal changes, which is highly relevant in clinical scenarios involving splint therapy.[11]

While surface EMG is often employed for masseter and temporalis, it lacks accuracy in deeper muscles like ILP due to anatomical positioning and interference from adjacent muscular activity.[6] This study uniquely employed intramuscular fine-needle EMG, offering superior precision in targeting the ILP, albeit with challenges including discomfort, technical expertise, and risk of anatomical variability. Despite this, the use of fine-needle EMG allowed a focused evaluation of this critical muscle, filling a significant research gap.[9]

Few previous studies have specifically evaluated ILP activity due to the muscle's deep location, difficulty in accessing via EMG without invasive techniques, and clinician preference for more accessible muscles.[7,10] Moreover, past research has primarily centered on masseter and temporalis due to their larger bulk and clearer surface accessibility. The methodological complexity of targeting the ILP discouraged routine clinical use, making this study one of the few to investigate ILP response over a prolonged splint-wearing period.

Findings revealed a reduction in EMG activity in both hard and soft splint groups at 24 hours, which is consistent with studies showing splint-induced deprogramming of masticatory musculature.[5,14] At 8 weeks, hard splints continued to show a decrease in ILP activity, likely due to their stable occlusal interface and better control of mandibular posture. In contrast, soft splints exhibited a mild increase in ILP activity, possibly due to their compliance and reduced capacity to restrict maladaptive movement, aligning with who found that soft splints may not provide sufficient neuromuscular control.[14,15]

Although intramuscular EMG is considered more accurate for deep muscles like ILP, it is operator-dependent and requires anatomical expertise. Potential limitations include electrode misplacement, discomfort to the patient, and the limited number of readings due to invasiveness.[8,10] Despite these challenges, the data obtained are highly specific and clinically relevant.[9]

In the present study, we compared the effects of hard and soft occlusal splints on the EMG activity of the ILP in patients with mild to moderate occlusal wear. At 24 hours, both splint types significantly reduced ILP activity at rest and during clenching, aligning with earlier findings where occlusal devices were shown to immediately alter muscle tone and reduce hyperactivity.[5] This may be attributed to the temporary repositioning of the mandible and altered proprioceptive feedback delivered.

At the 8-week follow-up, hard splints continued to exhibit a sustained reduction in EMG activity, indicating prolonged neuromuscular deprogramming. Conversely, the soft splint group exhibited a mild resurgence in muscle activity, although statistically non-significant. Similar trends have been reported who found hard splints to be superior in managing myofascial pain dysfunction due to their rigid occlusal surface and stability.[7] Hard splints likely provide more consistent occlusal stabilization.

Interestingly, despite intra-group improvements, no statistically significant differences were found between the hard and soft splint groups. This may be attributed to the small sample size, limited follow-up duration, and individual variability in muscle responsiveness. Nonetheless, both splint types demonstrated the ability to modulate ILP muscle activity, supporting their use in managing occlusal instability and associated muscular dysfunctions.

This study is unique in evaluating the EMG response of the ILP muscle specifically an area often overlooked due to technical challenges in electrode placement. Our methodology relied on surface EMG data supported by clinical assessment, though needle EMG may offer improved specificity.[8]

Despite the promising trends, statistical insignificance in some comparisons could be due to the small sample size, short follow-up duration, and biological variability. Future investigations should incorporate larger cohorts, objective assessments of occlusal contact area and force, and longer-term follow-up, possibly integrating imaging like CBCT to correlate muscular changes with condylar adaptation.[4,11] EMG studies have consistently reported higher resting muscle activity and reduced maximum voluntary contraction in patients with TMDs, suggesting neuromuscular imbalance.[3]

Limitations of this study include its small cohort, reliance on intramuscular EMG for a deep muscle, and lack of long-term follow-up.

5. Conclusion

Splints helped in achieving a harmonious effect on muscle activity. The effect of hard splint use was more pronounced on the Lateral Pterygoid activity than soft splint. Objective evaluation of muscle activity may be considered in patients undergoing permissive splint therapy to ensure better stability of the stomatognathic system. Preferred duration of wear of hard splints of up to 8 weeks can be suggested before patients undergo definitive therapy.

6. Conflict of Interest

None.

7. Source of Funding

None.

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