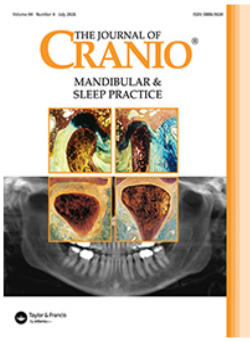

CRANIO®
The Journal of Craniomandibular & Sleep Practice

ISSN: 0886-9634 (Print) 2151-0903 (Online) Journal homepage: www.tandfonline.com/journals/ycra20

Functional analysis of masticatory muscles after intraoral proportional condylectomy

Orion Luiz Haas Junior, Jaqueline Colaço, Rubens Martins Bastos , Adaia Valls-Ontañón, Federico Hernández-Alfaro , Bibiana Mello da Rosa , Rogério Belle de Oliveira & Rafael Reimann Baptista

CRANIO®: THE JOURNAL OF CRANIOMANDIBULAR & SLEEP PRACTICE
https://doi.org/10.1080/08869634.2026.2685840

RESEARCH ARTICLE

Functional analysis of masticatory muscles after intraoral proportional condylectomy

Orion Luiz Haas Junior, DDS MSc PhD [a,b*], Jaqueline Colaço, DDS MSc [c*], Rubens Martins Bastos, DDS MSc[a,b], Adaia Valls-Ontañón [d,e], Federico Hernández-Alfaro, DDS MSc PhD[d,e], Bibiana Mello da Rosa, DDS MSc PhD[a,b], Rogério Belle de Oliveira, DDS MSc PhD[a,b] and Rafael Reimann Baptista, MSc PhD[c]

[a]Belle & Haas Orthofacial Surgery Centre, Porto Alegre, Brazil; [b]Oral and Maxillofacial Surgery, Hospital São Lucas, Porto Alegre, Brazil; [c]Department of Post-Graduate Dentistry, Pontifical Catholic University of Rio Grande do Sul, Porto Alegre, Brazil; [d]Department of Oral and Maxillofacial Surgery, Universitat Internacional de Catalunya (UIC), Barcelona, Spain; [e]Institute of Maxillofacial Surgery, Teknon Medical Center, Barcelona, Spain

ABSTRACT

Objective: To evaluate muscle activity during maximum voluntary clenching (MVC) in patients treated with intraoral proportional condylectomy and minimally invasive orthognathic surgery, assessing neuromuscular balance between operated and contralateral sides.
Methods: Thirteen patients (11 women; mean age 28.2 ± 5.23 years) were evaluated. Electromyographic activity of the masseter and anterior temporalis muscles was recorded using the Teethan® system during MVC. Asymmetry, POC, impact, and global indices were analyzed. Maximum mouth opening was measured, and sides were compared using paired t-tests ($p < .05$).
Results: Mean maximum mouth opening was 39.6 ± 4.05 mm, with a median follow-up of 2 years. No significant differences were found between sides for anterior temporalis (23.69 ± 3.01 vs 25.37 ± 2.60; $p = .161$) or masseter activity (25.52 ± 4.11 vs 25.26 ± 3.22; $p = .887$). The global index was 85.90 ± 3.43 and asymmetry index 0.17 ± 8.04.
Conclusion: This combined approach preserved neuromuscular balance during MVC, supporting its role as a functionally conservative treatment.

KEYWORDS
Orthognathic surgery; condylectomy; electromyography

Introduction

Condylectomy is indicated for the treatment of active condylar hyperplasia and benign and malignant tumors of the temporomandibular joint (TMJ) [1,2]. Many surgical techniques have been described in the literature, with extraoral or intraoral approaches, partial or complete excision of the mandibular condyle, with or without repositioning of the articular disc, and combining orthognathic surgery when necessary [3–5].

The intraoral proportional condylectomy integrates virtual surgical planning with computer-aided design (CAD) and manufacturing (CAM) technology; cone-beam computed tomography (CBCT) is utilized to assess the vertical discrepancy between the hyperplastic and normal sides of the mandible and mirror the vertical height of the unaffected side, enabling the creation of a custom 3D-printed cutting guide tailored to the anatomy of the affected area [6]. This surgical technique reduces the risk of neurovascular complications, prevents facial scarring, avoids the damage that extraoral approaches can cause, and preserves the integrity of the articular capsule, allowing for lower patient morbidity and a smoother postoperative recovery while offering a precise and efficient surgical option [6–8].

Whether patients are able to regain normal mandibular movements after condylectomy is a concern, and electromyography is the examination of choice to identify muscle activity. Specific electromyographic indices allow for the assessment of muscle function symmetry [9]. Electromyographic analysis of masticatory muscles following this procedure is particularly scarce in the literature. This significant gap in knowledge underscores the need for further investigation. Therefore, this study aims to estimate muscle activity during maximal muscle contraction in patients who underwent intraoral proportional condylectomy concurrent with minimally invasive orthognathic surgery and to identify whether there is a neuromuscular balance between the operated and non-operated condyle sides.

CONTACT Jaqueline Colaço jaqueccolaco@gmail.com Department of Post-Graduate Dentistry, Pontifical Catholic University of Rio Grande do Sul. Avenida Ipiranga, 6681, Partenon – Porto Alegre, Porto Alegre, Rio Grande do Sul 90690-000, Brazil
*Both authors contributed equally.

Materials and methods

Ethics statement

The study protocol was approved by the Research Ethics Committee (approval number 6,182,492). All procedures followed the Helsinki Declaration guidelines. All participants were fully informed of the possible risks and benefits of their involvement in the study and gave their written consent to participate.

Study design/sample

Patients who underwent unilateral intraoral proportional condylectomy and concomitant orthognathic surgery at the Belle & Haas Orthofacial Surgery Center, with at least 1 year of follow-up, were recruited for the study. Patients with a history of facial trauma and reconstructive surgeries of the temporomandibular joint were excluded. All patients included in the study presented no symptoms of temporomandibular dysfunction, with no muscle or joint pain, no clicking or crepitus, and no limitations during mandibular movements. Furthermore, the patients showed no alterations in the non-operated condyle.

Variables

The predictor variable in this study was the condylectomy surgical site, categorized as either the right or left side. The main outcome variable was the electromyographic activity of the masseter and anterior temporalis muscles. Additionally, age, sex, mouth opening and follow-up duration were considered covariates.

Surgical planning and procedure

All patients underwent bone scintigraphy, which identified the pathology in its active phase. Using computed tomography imported into the 3D Dolphin software, virtual planning was performed for proportional intraoral condylectomy according to the technique published by Haas Junior [7]. All surgical procedures were performed by the same surgeons, RB and OH. The virtual planning for proportional intraoral condylectomy involved measuring the height of the mandibular rami bilaterally to fabricate the cutting guide. The first step in the surgical procedure was the intraoral approach for condylectomy [6], and fitting the cutting guide onto the sigmoid ramus for coronoidectomy, followed by condylectomy using piezosurgery. The second step was minimally invasive orthognathic surgery with Hunsuck mandibular osteotomy [10] and hybrid fixation using one plate and one bicortical screw, followed by the twist technique for maxillary surgery [11] with fixation using one plate on each side at the nasomaxillary buttress [12]. In all cases, suturing was performed with resorbable suture material.

Electromyographic evaluation

Electromyographic evaluation was performed in all patients who underwent the surgical procedure with at least one and a half years of follow-up. Electromyographic activity was measured using the Teethan® system (BTS SpA, Garbagnate Milanese, Italy). The Teethan® 3.0 software includes specific evaluation indices for the masseter and anterior temporalis muscles and was developed based on studies by Ferrario et al. [13–17].

Recorded signals were processed and normalized according to a standardized clenching protocol. Although the indices were automatically calculated by the software, their mathematical formulations are reported below. The Percentage Overlapping Coefficient (POC) index was used to assess the symmetry of activation in maximum voluntary contraction (MVC) between homologous muscles on the right and left sides and is defined as:

$$POC = \left[1 - \frac{\sum_{I=1}^{60} (Right\ muscle_i - Left\ muscle_i)}{\sum_{I=1}^{60} (Right\ muscle_i + Left\ muscle_i)} \right] \times 100$$

Where R_i and L_i represent the electromyographic activity of the right and left muscles, respectively, at each sampling interval i, and Σ indicates the summation over the recording period. The ratio $\Sigma\ |R_i - L_i| / \Sigma\ (R_i + L_i)$ expresses the proportion of non-overlapping activity between the two signals, and the POC represents the percentage of overlap between them. Values close to 100% indicate greater symmetry in muscle activation, while lower values reflect increasing asymmetry. In this study, the POC was developed globally and for each muscle pair individually, including the masseter and anterior temporalis [9,13–17].

The asymmetry index was selected to compare muscular activity in MVC of the masseter and anterior temporalis muscles between the right and left sides and was calculated automatically by the Teethan® software based on the following equation:

$$Astot = \left[\frac{MMR + TAR - MML - TAL}{MMR + TAR + MML + TAL} \right] \times 100$$

Where MMR and MML correspond to the right and left masseter muscles, and TAR and TAL correspond to the right and left anterior temporalis muscles. Results range from −10% to +10%; positive values indicate greater activity on the right side, whereas negative values reflect higher activation on the left. Values close to zero indicate balanced bilateral muscle activity [9,13–16]. The Impact index, proportional to bite force, was also evaluated. Normal values range from 100% to 115%. Higher values may indicate a hyperactive muscle pattern, while lower values may be associated with proprioceptive protection or protective nociceptive reflexes [9,13–17]. The global index was used to provide a comprehensive analysis of overall muscle activity. It represents the combined activity of the right and left masseter and temporalis muscles and is color-coded: green represents a global balance above 83%, yellow between 82% and 75%, and red below 74%. Muscle activity in MVC generated by the Teethan software is also represented by a pie chart. In the presence of good neuromuscular balance and absence of malocclusion, the chart colors are evenly distributed across the four quadrants, with each sector occupying 25%9. All indices were obtained automatically by the Teethan® software following signal acquisition and normalization procedures, ensuring standardized and reproducible electromyographic analysis under controlled occlusal conditions.

Electromyographic protocol

As recommended by the SENIAM protocol, the participants were seated upright, ensuring their heads remained unsupported and their legs uncrossed. Skin preparation at the electrode placement sites was performed with 70% alcohol. In accordance with SENIAM recommendations, wireless bipolar surface electrodes, each 10 mm in diameter, were used in the study and applied along the muscle fibers with a spacing of 20 mm between them. Electrode placement was determined by palpation during maximal clenching of the teeth. Electrodes for the masseter muscle were placed in alignment with the direction of the muscle fibers. In contrast, for the anterior temporalis muscle, the electrodes were placed 2 cm away from the zygomatic process, ensuring precise positioning for accurate data collection. For calibration, a 10 mm diameter cotton roll was placed between teeth 35 and 36 and 45 and 46, and patients were instructed to perform maximal muscle contractions for 5 s. Next, the cotton swabs were removed from the mouth and the patient rested for 3 min, after which the static test was performed in which the patient was instructed to perform maximum muscle contraction in dental occlusion for 5 s. To avoid muscle fatigue, a 3-min rest interval was given between each test, and the static MVC test was repeated three times.

Mouth openning

Using a caliper, the maximum mouth opening was measured by taking the distance from the incisal edge of tootht 11 to the incisal edge of tooth 41.

Statistical analyses

The Shapiro–Wilk test was used to evaluate the normality of distribution of the quantitative variables. Data are presented as means and standard deviations. A paired t-test was conducted to compare the right and left sides, and an independent samples t-test was used to compare the sites of condylectomy. Statistical significance was established at a two-tailed p-value less than 0.05. All statistical analyses were conducted in SPSS version 27.0 (IBM Corp., Armonk, NY, USA).

Sample power calculation

Considering that the number of patients available for the study was 13, a sample size calculation was performed to verify the adequacy of this sample size for estimating the mean asymmetry index. A margin of error of 12%, a confidence level of 95%, and an expected standard deviation of 19.45% were adopted, as described by Saracutu et al. [9]. The calculation was performed using the online version of the PSS Health tool. This approach allowed for the evaluation of the descriptive power of the available sample, ensuring greater robustness in the interpretation of the results.

Results

All patients evaluated had already fully recovered from the surgical procedure, had no complaints of pain, did not present any temporomandibular dysfunction, with a minimum follow-up period of 1.5 years, and already had stable dental occlusion. Thirteen patients (11 female) participated in the study, with a mean age of 28.2 years (SD 5.23). The mean maximum mouth opening was 39.6 mm (SD 4.05) and the median follow-up period was 2 years as shown in Table 1.

There was no statistical difference when comparing right and left temporalis activity (mean 23.69 ± 3.01 and 25.37 ± 2.60, respectively; $p = .161$). Likewise, for the masseter muscle, there was no significant difference when comparing the right and left sides (mean 25.52 ± 4.11 and 25.26 ± 3.22, respectively; $p = .887$). The mean (SD) global index was 85.90 ± 3.43 and the asymmetry index was 0.17 ± 8.04. The mean (SD) POC MM was 83.3 ± 3.1 and for POC TA 80.6 ± 86.1 and for the Impact index 89.3 ± 103.2 as shown in Table 2.

Table 1. Description of the sample characteristics in individuals who underwent condylectomy.

Patient	Sex	Age	Mouth opening (mm)	Follow up (Years)	Condylectomy	CH Classification18
1	F	26	38	1	Right	Type 1B
2	F	36	40	7	Right	Type 2A
3	F	30	48	3	Right	Type 1B
4	F	26	36	7	Left	Type 1B
5	F	30	45	4	Right	Type 1B
6	F	26	39	2	Right	Type 1B
7	F	25	38	4	Left	Type 1B
8	F	31	40	3	Right	Type 2B
9	F	29	36	1	Right	Type 1B
10	F	36	40	2	Right	Type 1B
11	M	23	41	1	Left	Type 1B
12	M	32	42	2	Left	Type 1B
13	F	17	32	1	Right	Type 1B
Mean	11F/2 M	28.2	39.62	2 (1–7)	9 R/4 L	Type 1B
SD	–	5.2	4.05		-	

Legend: M: male; F: female; R: right; L: left; SD: standard deviation.
CH classification.
Type 1B: unilateral horizontal condylar overgrowth.
Type 2A: unilateral vertical condylar enlargement without exophytic tumor.
Type 2B: unilateral vertical condylar enlargement with exophytic tumor growth.

Table 2. Electromyographic evaluation of the masseter and anterior temporalis muscles in individuals who underwent condylectomy.

Patient	Follow up (Years)	Muscle Activity RT	Muscle Activity LT	Muscle Activity RM	Muscle Activity LM	Global index	Asymmetry Index (%)	Condylectomy	POC MM (%)	POC TA (%)	Impact (%)
1	1	23.3	25	29	22	83	2.48	Right	82.4	71.1	97.2
2	7	24.6	26	23.6	26	91	−1.79	Right	80.0	90.3	108.3
3	3	24.3	22.6	27.3	25.6	86	3.73	Right	85.6	84.7	109.6
4	7	22	29.6	24.6	23.3	86.3	−6.32	Left	82.9	86.0	85.0
5	4	22.3	29.6	20.3	27.6	85.3	−12	Right	80.0	80.0	84.0
6	2	22.3	25.3	22.6	29.3	79	3.87	Right	79.0	86.3	100.0
7	4	20	28	22	30	87	−15.36	Left	82.4	83.1	95.0
8	3	24.3	23.3	22.3	30	85	−6.72	Right	80.6	86.2	106.4
9	1	18	21.6	36	24.3	80.6	8.44	Right	83.2	83.1	80.5
10	2	24.3	25.3	28	22.3	89.6	10.27	Right	89.7	80.7	118.0
11	1	30	27	23	20	88	5.34	Left	85.2	83.2	90.0
12	2	27	23	27	23	89	7.98	Left	85.2	83.9	89.0
13	1	25.5	23.5	26	25	87	2.29	Right	86.6	85.2	88.0
Mean	2 (1–7)	23.68	25.36	25.51	25.26	85.90	0.17	9 R/4 L	83.3	83.4	96.2
SD		3.01	2.60	4.11	3.21	3.43	8.04		3.1	4.5	11.5
95% CI	–	21,86 to 25,50	23,79 to 26,94	23,02 to 28,00	23,31 to 27,20	83,83 to 87,98	−4,69 to 5,03		81.4 to 85.2	80.6 to 86.1	89.3 to 103.2
Teethan reference values	–	25%	25%	25%	25%	–	−10<(%) <+10)	–	83<(%) <100)	83<(%) <100)	85<(%) <115)

Legend: R: right; L: left; RT: right temporal; LT: Left temporal; RM: right masseter; LM: left masseter; SD: standard deviation; CI: confidence interval.
Grey box: Global Index above 83%; Yellow box: Global Index between 82% and 74%.
Asymmetry index: Compares the activity of the right and left muscles.
POC MM index: symmetry between homologous muscles, the right and left masseter during MVC.
POC TA index: symmetry between homologous muscles, the right and left anterior temporal during MVC.
Impact: It indicates the work of the masticatory muscles and is proportional to the bite force.

Table 3. Comparative analysis of muscle activity in the temporalis and masseter muscles in patients undergoing condylectomy.

		Right Condylectomy $n = 9$	Left Condylectomy $n = 4$	95% CI	p
Anterior Temporal					
	Right	23.21 ± 2.22	24.75 ± 4.57	−8,474 to 5,396	0.560
	Left	24.69 ± 2.34	26.90 ± 2.81	−5,491 to 1,068	0.166
Masseter					
	Right	26.12 ± 4.72	24.15 ± 2.18	−3,558 to 7,502	0.449
	Left	25.79 ± 2.80	24.08 ± 4.22	−2,585 to 6,013	0.399

Legend: CI: confidence interval; Red box: greater muscle activity on the healthy side; Blue box: greater muscle activity on the condylectomy side.

When comparing the right and left sides as condylectomy surgical sites, there was no statistically significant difference in temporalis activity between right and left ($p = .560$ and $p = .166$), neither for the masseter ($p = .449$ for the right side and $p = .399$ for the left). These data are presented in Table 3.

Discussion

Condylectomy is the surgical procedure of choice for the treatment of hyperplasia and benign tumors of the mandibular condyle, with its main objective being complete resection of pathological areas and restoration of facial symmetry [7,19–22]. Considering the surgical goals of treating condylar hyperplasia, all patients in this study were successfully treated using the intraoral proportional condylectomy technique, with all achieving facial symmetry and no cases of recurrence. The success of treatment in these patients can be attributed to the use of a series of virtual tools that aid in surgical predictability, such as virtual planning [7,23], virtual segmentation of the condyle to ensure that all pathology would be removed [24], and use of CAD/CAM cutting guides [7,25]. Another major goal after condylectomy is to effectively reestablish masticatory function without any irreversible damage to mouth opening or to the muscles of mastication [1,2,20,26]. The present study does not aim to diagnose temporomandibular disorders or define functional recovery, but rather to describe neuromuscular behavior through electromyographic assessment in patients who underwent condylectomy combined with orthognathic surgery. All patients included in this study were clinically asymptomatic and had their dental occlusion re-established following orthognathic surgery. In this study, patients demonstrated a satisfactory mandibular range of motion following condylectomy, with a mean maximum mouth opening of 39.2 mm. This finding suggests adequate functional adaptation and is consistent with a balanced neuromuscular condition under the evaluated clinical parameters.

In all cases, coronoidectomy was performed prior to condylectomy for direct access to the condyle and placement of cutting guides (when planned). Resection of the coronoid involves detachment of a portion of the anterior temporalis tendon at the mandible. The temporalis muscle is divided into anterior and posterior portions, with the anterior portion performing the movement of mandibular protrusion and the posterior portion responsible for mandibular retraction [27]. On electromyographic assessment, the index that determines temporalis muscle activity – the POC TA – evaluates the function of the anterior portion of the muscle; its results were within normal limits, suggesting preservation of efficient neuromuscular balance in MVC after the coronoidectomy–condylectomy procedure. Therefore, electromyographic recordings obtained during maximum voluntary contraction were performed under stable occlusal conditions, without the influence of occlusal interferences or functional disturbances. In this context, the data collected fell within the normal range of the indices and can be interpreted as an expression of neuromuscular balance.

In this study, we employed a minimally invasive condylectomy approach [7], a technique that involves less detachment of the masseter muscle during surgical access, osteotomies, and, at the orthognathic surgery stage, fixation; this also helped preserve the normality of the masseter muscle. The masseter muscle is responsible for elevating and stabilizing the jaw, as well as contributing to its protrusion [28]. The results of the electromyography of the POC MM index in MVC, which assesses the symmetry of muscle activity between the right and left masseter muscles, were within normal limits, suggesting neuromuscular balance. In the presence of occlusal interference, asymmetry in muscle activity can occur [16]. The data from the present study indicated that the Impact index, which is equivalent to an assessment of bite force, POC MM, POC TA, and Asymmetry, which assess the symmetry of muscle activity, were within the normal range. This can be interpreted as neuromuscular balance, which may be adaptive, where stable dental occlusion was achieved through orthognathic surgery and is an important part of ensuring that the muscles are activated in a balanced way.

The Global Index of neuromuscular balance of the masseter and anterior temporalis muscles yielded an average of 85%, demonstrating a good balance between the activity of the two muscle pairs evaluated and, therefore, suggesting that there is neuromuscular balance when assessing that the muscle activity in the condylectomy site did not differ from that in the non-operated region. The findings of this study, which had a follow-up of at least 1 year after surgical intervention, are similar to those of the only other study on the subject which we found in the literature, a case report published by Cullati et al. [19] in 2017, in which electromyographic evaluation was performed prior to condylectomy and orthognathic surgery and the authors identified asymmetric patterns of muscle activity preoperatively, which became normal 24 months after the procedure.

The symmetry of muscle function between the right and left sides of the patient is measured in Teethan®

using the asymmetry index, which standardizes values between −10% and +10% as normal, although negative values tend to indicate greater activity on the left side and positive values on the right side. In this study, in the static evaluation in MVC, the variation remained within the normal symmetry pattern, since perfectly symmetrical function between muscle groups does not exist [29]. These results may suggest a neuromuscular balance through adaptation, since intraoral condylectomy with concomitant orthognathic surgery re-established a stable dental occlusion.

The intraoral proportional condylectomy technique used in this study is an effective, minimally invasive treatment approach. Studies have shown that, within 12 months of the procedure, the operated condyle undergoes sufficient recorticalization to resemble the healthy, non-operated side in size [22]. Some studies report that after the proportional condylectomy procedure performed via an extraoral approach, some discrepancies in the mandibular lower border and ramus height were found [27], which could lead the patient to a second surgical stage for correction with orthognathic surgery. The proportional intraoral condylectomy technique performed in this study aims to reestablish condylar height and correct the facial asymmetry through orthognathic surgery. In the present study, all patients were evaluated at least 1 year after surgery and none required reintervention or a second surgical procedure. The integration of virtual planning, CAD/CAM technology, and precise intraoral approach enhances surgical predictability, reduces morbidity and optimizes recovery [6,7,25]. Therefore, electromyographic assessment showed no statistically significant difference in muscle activity between the side on which condylectomy was performed and the contralateral, non-operated side. It is important to note that all patients had their dental occlusion re-established, as they also underwent orthognathic surgery and there were no symptoms of temporomandibular dysfunction. In the Impact index, which assesses bite force in MVC, the results obtained were within the normal range, meaning there was no muscle force below or above normal. These results may suggest good neuromuscular adaptation after a long period following intraoral proportional condylectomy procedures with orthognathic surgery.

This study has some limitations, such as loss to follow-up. The original sample consisted of 15 patients. However, two patients were unable to attend the clinic to participate in study evaluations. In addition, assessments were performed at only one time point and the absence of baseline electromyographic data precludes direct comparison between pre- and postoperative conditions, and the lack of comprehensive clinical and patient-reported outcomes should be taken into account when interpreting the findings. In the present study, the clinical evaluation was limited to the range of mandibular motion, specifically the maximum mouth opening.

The interpretation of electromyographic findings in patients with temporomandibular disorders and related surgical procedures should be performed with caution. Recent evidence-based recommendations published by the International Network for Orofacial Pain and Related Disorders Methodology (INfORM) and the IADR emphasized that instrumental assessments such as surface electromyography, kinesiography, and posturography are generally not supported by current scientific evidence as reliable diagnostic tools for temporomandibular disorders, reinforcing that clinical examination and patient-reported symptoms remain the standard of care for diagnosis and management [30]. Although surface electromyography may provide complementary information regarding muscle activation patterns, its diagnostic and clinical applicability remains controversial. Daniele Manfredini et al. [31] demonstrated that several electromyographic and kinesiographic parameters, including resting muscle activity, symmetry indices, and jaw movement recordings, showed low diagnostic accuracy and high false-positive rates in distinguishing patients with myofascial pain from asymptomatic subjects, concluding that such instruments should not be used as stand-alone diagnostic tools due to the risk of overdiagnosis and overtreatment. The authors also emphasized that reductions in EMG activity during clenching tasks may reflect adaptive responses to pain rather than objective indicators of dysfunction. Similarly, Charles S. Greene and Daniele Manfredini [32] highlighted that instrumental assessments alone are not directly related to the actual medical necessity for treatment and warned against mechanistic interpretations based exclusively on occlusal or neuromuscular parameters. Furthermore, Charles S. Greene and Daniele Manfredini [33] discussed the potential risk of overtreatment associated with excessive reliance on technological diagnostic devices, particularly when irreversible therapeutic decisions are based on findings lacking robust biological validity. Therefore, the present results should be interpreted as complementary functional observations rather than definitive indicators of treatment success or neuromuscular balance. It should also be emphasized that the patients included in the present study presented condylar tumors associated with facial asymmetry and were evaluated in the absence of signs and symptoms of temporomandibular disorders, which must be considered when interpreting the electromyographic findings.

One limitation of the present study was the absence of assessment of electromyographic repeatability, which may have influenced the reproducibility and reliability of the obtained measurements. Within the limitations of this study, electromyographic assessment demonstrated suggests the absence of detectable side-to-side differences under the conditions tested during maximum voluntary contraction, suggesting a balanced neuromuscular pattern under standardized conditions. Considering that all patients were clinically asymptomatic and had a re-established dental occlusion following orthognathic surgery, the findings reflect functional adaptation rather than direct evidence of complete functional recovery. Electromyography proved to be a useful complementary tool for assessing neuromuscular coordination; however, its findings should be interpreted with caution and not as a standalone indicator of clinical function.

Author contributions

CRediT: **Jaqueline Colaço DDS MSc:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Resources, Validation, Writing – original draft, Writing – review & editing; **Rubens Martins Bastos DDS MSc:** Conceptualization, Data curation, Formal analysis, Supervision, Validation, Visualization; **Adaia Valls-Ontañón:** Conceptualization, Data curation, Formal analysis, Project administration, Software, Validation, Visualization; **Federico Hernández-Alfaro DDS MSc PhD:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Resources, Supervision, Validation, Visualization; **Bibiana Mello da Rosa DDS MSc PhD:** Conceptualization, Data curation, Formal analysis, Supervision, Validation, Visualization; **Rogério Belle de Oliveira DDS MSc PhD:** Conceptualization, Data curation, Formal analysis, Methodology, Supervision, Validation, Visualization; **Rafael Reimann Baptista MSc PhD:** Conceptualization, Data curation, Formal analysis, Project administration, Software, Supervision, Validation, Visualization, Writing – review & editing.

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This study was financed in part by the Coordination for the Improvement of Higher Education Personnel – Brazil (CAPES) – Finance Code 001.

ORCID

Jaqueline Colaço DDS MSc http://orcid.org/0000-0003-3504-8402
Adaia Valls-Ontañón http://orcid.org/0000-0003-4065-7405

References

[1] Kim JY, Kim SG, Park HS, Lee SW. Condylectomy as the treatment for active unilateral condylar hyperplasia of the mandible and severe facial asymmetry: retrospective review over 18 years. Int J Oral Maxillofac Surg. 2019;48(12):1542–1551. doi: 10.1016/j.ijom.2019.06.022
[2] Wolford LM, Mehra P, Franco P. Use of conservative condylectomy for treatment of osteochondroma of the mandibular condyle. J Oral Maxillofac Surg. 2002;60(3):262–268. doi: 10.1053/joms.2002.30570
[3] Wolford LM, Mehra P, Reiche-Fischel O, et al. Efficacy of high condylectomy for management of condylar hyperplasia. Am J Orthod Dentofac Orthop. 2002;121(2):136–151. doi: 10.1067/mod.2002.118403
[4] Appel T, Niederhagen B, Braumann B, et al. High condylectomy for control of pathological growth in condylar hyperplasia. Mund Kiefer Gesichtschir. 1997;1 Suppl 1(Suppl 1):SS138–S40.
[5] Nitzan DW, Katsnelson A, Bermanis I, et al. The clinical characteristics of condylar hyperplasia: experience with 61 patients. J Oral Maxillofac Surg. 2008;66(2):312–318. doi: 10.1016/j.joms.2007.08.046
[6] Hernández-Alfaro F, Guijarro-Martínez R, Peiró-Guijarro MA, et al. Minimally invasive intraoral condylectomy: proof of concept report. Int J Oral Maxillofac Surg. 2016;45(9):1108–1114. doi: 10.1016/j.ijom.2016.04.001
[7] Haas Junior OL, Guijarro-Martínez R, Hernández-Alfaro D, et al. Minimally invasive intraoral proportional condylectomy with a three-dimensionally printed cutting guide. Int J Oral Maxillofac Surg. 2020;49(11):1435–1438. doi: 10.1016/j.ijom.2020.06.015
[8] Luo NJ, Li J, Zhang L, et al. Imaging analysis of temporomandibular joint anatomy changes after intraoral condylectomy combined with orthognathic surgery. Zhonghua Kou Qiang Yi Xue Za Zhi. 2016;51:350–354. doi: 10.3760/cma.j.issn.1002-0098.2016.06.007
[9] Saracutu OI, Pollis M, Cagidiaco EF, et al. Repeatability of Teethan® indexes analysis of the masseter and anterior temporalis muscles during maximum clenching: a pilot study. Clin Oral Investig. 2023;27(9):5309–5316. doi: 10.1007/s00784-023-05150-8
[10] Hunsuck EE. A modified intraoral sagittal splitting technic for correction of mandibular prognathism. J Oral Surg. 1968;26(4):250–253.
[11] Hernández-Alfaro F, Guijarro-Martínez R. "Twist technique" for pterygomaxillary dysjunction in minimally invasive Le fort I osteotomy. J Oral Maxillofac Surg. 2013;71(2):389–392. doi: 10.1016/j.joms.2012.04.032
[12] Susarla SM, Ettinger R, Preston K, et al. Two-point nasomaxillary fixation of the Le Fort I osteotomy: assessment of stability at one year postoperative. Int J Oral Maxillofac Surg. 2020;49(4):466–470. doi: 10.1016/j.ijom.2019.08.006
[13] Ferrario VF, Sforza C, D'Addona A, et al. Electromyographic activity of human masticatory muscles in normal young people. Statistical evaluation of reference values for clinical applications. J Oral Rehabil.

1993;20(3):271–280. doi: 10.1111/j.1365-2842.1993.tb01609.x
[14] Ferrario VF, Sforza C, Serrao G. The effects of a single intercuspal interference on electromyographic characteristics of human masticatory muscles during maximal voluntary teeth clenching. J Oral Rehabil. 1999;17(3):184–188. doi: 10.1080/08869634.1999.11746093
[15] Ferrario VF, Sforza C, Colombo A, et al. An electromyographic investigation of masticatory muscles symmetry in normo-occlusion subjects. J Oral Rehabil. 2000;27(1):33–40. doi: 10.1046/j.1365-2842.2000.00490.x
[16] Ferrario VF, Serrao G, Dellavia C, et al. Relationship between the number of occlusal contacts and masticatory muscle activity in healthy young adults. Cranio. 2002;20(2):91–98. doi: 10.1080/08869634.2002.11746196
[17] Ferrario VF, Sforza C, D'Addona A, et al. Reproducibility of electromyographic measures: a statistical analysis. J Oral Rehabil. 1991;18(6):513–521. doi: 10.1111/j.1365-2842.1991.tb00074.x
[18] Wolford LM, Movahed R, Perez DE. A classification system for conditions causing condylar hyperplasia. J Oral Maxillofac Surg. 2014;72(3):567–595. doi: 10.1016/j.joms.2013.09.002
[19] Cullati F, Mapelli A, Beltramini G, et al. Surface electromyography before and after orthognathic surgery and condylectomy in active laterognathia: a case report. Eur J Paediatr Dent. 2017;18(2):131–138. doi: 10.23804/ejpd.2017.18.02.08
[20] Mehra P, Arya V, Henry C. Temporomandibular joint condylar osteochondroma: complete condylectomy and joint replacement versus low condylectomy and joint preservation. J Oral Maxillofac Surg. 2016;74(5):911–925. doi: 10.1016/j.joms.2015.11.028
[21] Niño-Sandoval TC, Maia FPA, Vasconcelos BCE. Efficacy of proportional versus high condylectomy in active condylar hyperplasia: a systematic review. J Craniomaxillofac Surg. 2019;47(8):1222–1232. doi: 10.1016/j.jcms.2019.03.024
[22] Fariña R, Moreno E, Lolas J, et al. Three-dimensional skeletal changes after early proportional condylectomy for condylar hyperplasia. Int J Oral Maxillofac Surg. 2019;48(7):941. doi: 10.1016/j.ijom.2019.01.016
[23] Haas OL, Becker OE, de Oliveira RB. Computer-aided planning in orthognathic surgery—systematic review. Int J Oral Maxillofac Surg. 2015;44(3):329. doi: 10.1016/j.ijom.2014.10.025
[24] Méndez-Manjón I, Haas Junior OL, Guijarro-Martínez R, et al. Semi-automated three-dimensional condylar reconstruction. J Craniomaxillofac Surg. 2019;30(8):2555. doi: 10.1097/SCS.0000000000005781
[25] Si J, Zhang C, Tian M, et al. Intraoral condylectomy with 3D-printed cutting guide versus with surgical navigation: an accuracy and effectiveness comparison. J Clin Med. 2023;12(11):3816. doi: 10.3390/jcm12113816
[26] De Felício CM, Ferreira CLP, Medeiros APM, et al. Electromyographic indices, orofacial myofunctional status and temporomandibular disorders severity: a correlation study. J Electromyogr Kinesiol. 2012;22(2):266–272. doi: 10.1016/j.jelekin.2011.11.013
[27] Abboud WA, Krichmar M, Blinder D, et al. Three-dimensional orofacial changes occurring after proportional condylectomy in patients with condylar hyperplasia type 1b (unilateral hemimandibular elongation). J Oral Maxillofac Surg. 2019;77(4):803–817. doi: 10.1016/j.joms.2018.11.006
[28] Gagnani SP, Yadav P, Roychoudhury A, et al. Longitudinal electromyographic changes in masseter and anterior temporalis muscle before and after temporomandibular joint arthroplasty in ankylosis patients. J Stomatol Oral Maxillofac Surg. 2021;122(6):573–577. doi: 10.1016/j.jormas.2020.09.015
[29] El Mozen M, Meng QG, Li YJ, et al. Condylar and occlusal changes after high condylectomy and orthodontic treatment for condylar hyperplasia. J Huazhong Univ Sci Technol [Med Sci]. 2015;35(2):265–270. doi: 10.1007/s11596-015-1422-5
[30] Manfredini D, Häggman-Henrikson B, Al Jaghsi A, et al. Temporomandibular disorders: inform/IADR key points for good clinical practice based on standard of care. Cranio. 2025;43(1):1–5. doi: 10.1080/08869634.2024.2405298
[31] Manfredini D, Cocilovo F, Favero L, et al. Surface electromyography of jaw muscles and kinesiographic recordings: diagnostic accuracy for myofascial pain. J Oral Rehabil. 2011;38(11):791–799. doi: 10.1111/j.1365-2842.2011.02218.x
[32] Greene CS, Manfredini D. Treating temporomandibular disorders in the 21st century: can we finally eliminate the "third pathway"? J Oral Facial Pain Headache. 2020;34(3):206–216. doi: 10.11607/ofph.2608
[33] Greene CS, Manfredini D. Overtreatment in orofacial musculoskeletal disorders: implications for patients, dentists, and the profession. J Oral Facial Pain Headache. 2023;37(2):81–90. doi: 10.11607/ofph.3290