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ORIGINAL ARTICLE

Impact of Mandibulectomy on Bite Function and Oral Health-Related Quality of Life: A Pilot Study

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Abstract

Introduction: Mandibulectomy is a critical surgical procedure for oral diseases but often results in impaired bite function, affecting eating and quality of life. This study investigates the relation between objective bite function and subjective oral-health related quality of life (OHRQoL) post-mandibulectomy.

Material and methods: Data were collected from eight patients six months post-segmental unilateral mandibulectomy. Bite function was assessed through a Digital Occlusal Force-Meter GM10, OMFT measuring station 430, the mixed nuts test and chewed wax test. OHRQoL was evaluated using the 14-item Oral Health Impact Profile (OHIP-14) questionnaire. Comparison was made between the reconstructed and non-reconstructed mandibular sides, further categorized based on dental arch shortening.

Results: OMFT measuring station 430 indicated a 35% decrease in masseter muscle function post-mandibulectomy, while the Digital Occlusal Force meter GM10 showed a 50% decline in overall bite force. Tongue and jaw function, assessed by the mixed peanuts test, experienced a minor 3% reduction. Patients with slightly shortened dental arches exhibited higher masseter muscle forces (1.8 ± 0.2N) compared to more severe shortening (extremely shortened: 0.4 ± 0.2N; moderately shortened: 0.7 ± 0.5N). This was also reflected in OHIP-14 scores, indicating physical pain and psychological discomfort (overall score = 30).

Discussion: Mandibulectomy resulted in diminished bite function, which correlated with both the resection and shortened dental arches. (S66516)

Keywords

Mandibular osteotomy, Mandibular reconstruction, Bite force, Mastication, Quality of Llife

Introduction

Mandibulectomy is frequently performed to address conditions such as infections (e.g., osteomyelitis), osteoradionecrosis following head and neck irradiation, trauma, bisphosphonate-related osteonecrosis, and tumors. However, a significant consequence of this procedure is the development of bite dysfunction [1]. In particular, bite forces are affected as patients not only lose dentition but also jawbone. Therefore, achieving hard tissue reconstruction following segmental or hemi-mandibulectomy becomes imperative for restoring bite function. Despite efforts to predict the extent of functional restoration, uncertainties persist regarding the outcomes, especially concerning the reconstructed side and the potential impact of dental arch shortening [2-4].

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Regarding the measurement of bite function, there is currently no established consensus. Traditionally, bite function has been evaluated using methods such as two-color chewing gum or mixed peanuts, or by measuring occlusal force [5-7]. However, these techniques are labor-intensive and often impractical to perform during routine follow-up. Therefore, there is a growing interest in transitioning to objective measurement devices, although the lack of reference values remains a challenge.

In addition to objective measurements, it is crucial to consider the patient's subjective experience. One widely accepted method for assessing patient-perceived impact across various oral and maxillofacial health conditions is the Oral Health Related Quality of Life (OHRQoL). The Oral Health Impact Profile-14 (OHIP-14) is the most used questionnaire for evaluating OHRQoL [8,9]. It encompasses 7 domains: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and overall handicap [10]. With a recommended recall interval of 7 days, the OHIP-14 enables the assessment of health changes over time [9,11].

The aim of the present study is to explore the impact of segmental unilateral mandibulectomy on bite function. This research involves a comparison between the bite function of the surgically treated side and the non-treated side of patients, while also examining the influence of dental arch length from both objective and subjective viewpoints. We anticipate that both the surgical resection and shortened dental arches will negatively affect bite function from both viewpoints.

Material and Methods

Patient population

The study enrolled adult patients who underwent unilateral mandibulectomy 6 months prior at the Oral and MaxilloFacial Surgery (OMFS) department of the University Hospitals of Leuven (Leuven, Belgium). Only cases of segmental unilateral mandibulectomy that excluded the condyle and involved bony flap reconstruction with a lack of dental rehabilitation were included. In this cross-sectional design, the bite function of the operated side was compared to the non-operated side.

The extent of the defect following segmental mandibulectomy was classified according to the Brown Classification [12]. Further categorization was based on the remaining dental arch. These groups were identified as having extremely shortened dental arches (0-2 occluding pairs), moderately shortened dental arches (3-4 occluding pairs), and slightly shortened dental arches (5-7 occluding pairs) [3]. For comparative purposes, only the dental arch from the operated side was considered. Clinical and demographic data, including sex (male, female), age (years), Brown classification, and reconstruction type, were extracted from medical records.

The experimental protocol received approval from the ethics committee of the University Hospitals of Leuven, Leuven, Belgium (26/09/2022; S66516) and was conducted in accordance with the principles of the Declaration of Helsinki. Prior to participation, each patient was fully informed of the study's objectives and provided written informed consent.

Objective assessment of the bite function

Bite force: Bite force was measured using the Digital Occlusal Force-Meter (GM10, Nagano Keiki Co., Japan) [13,14]. This device is recognized as a standard in objective bite function assessment, and has demonstrated reliability across various clinical populations, including patients with oral pathology and compromised dentition [15-17]. Measurements (in kilonewtons) were obtained from both anterior and posterior regions on the operated and non-operated sides. Patients were instructed to firmly bite down on the measurement tool once it was positioned between antagonistic elements. The instrument was calibrated prior to each session in accordance with the manufacturer’s guidelines. All assessments were performed by the same examiner to minimize inter-operator variability. For reporting purposes, all values obtained were converted to Newtons (N).

Additionally, the OMFT Measuring Station 430, which has been validated for orofacial muscle assessment [18], was employed to measure contraction force (in Newton) of the masseter muscle. The probe was placed extra-orally against the muscle group and patients were instructed to bite with maximum force. To minimize measurement error, standardized instructions were provided and all assessments were administered by the same examiner.

Tongue, lip and jaw function: The OMFT Measuring Station 430 is equipped to also assess tongue and lip force [18]. Lip compression is measured (in Newtons) by positioning the tool between the lips, without contacting the teeth. To measure tongue force, patients are instructed to push their tongue forward firmly while the probe is pressed against the lips.

Furthermore, the tongue and jaw function are evaluated using the protocol developed by Kapur et al. (1991) [5,6]. The nut-particle test followed a standardized procedure, which involves placing exactly one gram of mixed peanuts with various particle sizes in the buccal vestibule. Patients were then instructed to move their tongue and cheek muscles to transfer the nuts into a cup within a 10-second period. Any remaining particles were carefully collected with tweezers, dried for 24 hours, and subsequently weighed to determine the proportion the patient successfully removed from their mouth. This standardized approach ensured consistency across patients, with higher ratios indicating better tongue and jaw function.

Bite efficiency: To evaluate bite efficiency, Stockmar wax cubes (Stockmar, Sleeswijk-Holstein, Germany) were utilized. Identical cubes measuring 12 mm x 12 mm were cut from two contrasting colors (yellow and blue) and soaked in warm water at 45°C for one minute to facilitate chewing. Patients were instructed to chew the cubes exactly 10 times consecutively on their preferred side while maintaining an upright posture. Subsequently, the sample was photographed against a contracting background and compressed to 1 mm thick slices between two glass plates. To ensure reliability, two researchers independently conducted visual analysis following the classification system proposed by Schimmel and colleagues (2007) [7]. Bite efficiency got categorized into five classifications: chewing gum not mixed, impressions of cusps or folded once (SA1); large parts of chewing gum unmixed (SA2); bolus slightly mixed, but bits of unmixed original color (SA3); bolus well mixed, but color not uniform (SA4); bolus perfectly mixed with uniform color (SA5).

Subjective assessment of the bite function

The Oral Health Impact Profile (OHIP-14) comprises 14 questions organized into 7 categories to evaluate OHRQoL. These categories include functional limitations (OHIP 1 & 2), physical pain (OHIP 3 & 4), psychological discomfort (OHIP 5 & 6), physical disability (OHIP 7 & 8), psychological disability (OHIP 9 & 10), social disability (OHIP 11 & 12), and overall handicap (all 14 OHIP questions). Each question offers 5 response categories, ranging from "never" (score 0) to "very often" (score 4). A higher OHIP score indicates a lower quality of life related to oral health [19-23].

Statistical analysis

Descriptive statistics include the mean and standard deviation of all measured forces and the OHIP-scores.

Results

Patient characteristics

Out of the 36 consecutive treated patients, 8 were included in the present study (Figure 1). Table 1 provides details regarding patient demographics and measurements.

The average age of the patients was 68 ± 16 years, with a male-to-female ratio of 5:3. Five patients underwent Deep Circumflex Iliac Artery (DCIA) reconstruction, while the remaining three underwent Free Fibula reconstruction. According to the Brown classification, defect range distribution was evenly split between classes I and II. Half of the patient population had a moderately shortened dental arch, with 2 patients having an extremely shortened dental arch and 2 having a slightly shortened dental arch. Data from two patients (patients 1 and 6) were missing for the occlusal bite force measurements due to pain when biting, while patient 8 was unable to complete the tongue- and jaw-function test because of tongue hypersensitivity to the nut particles.

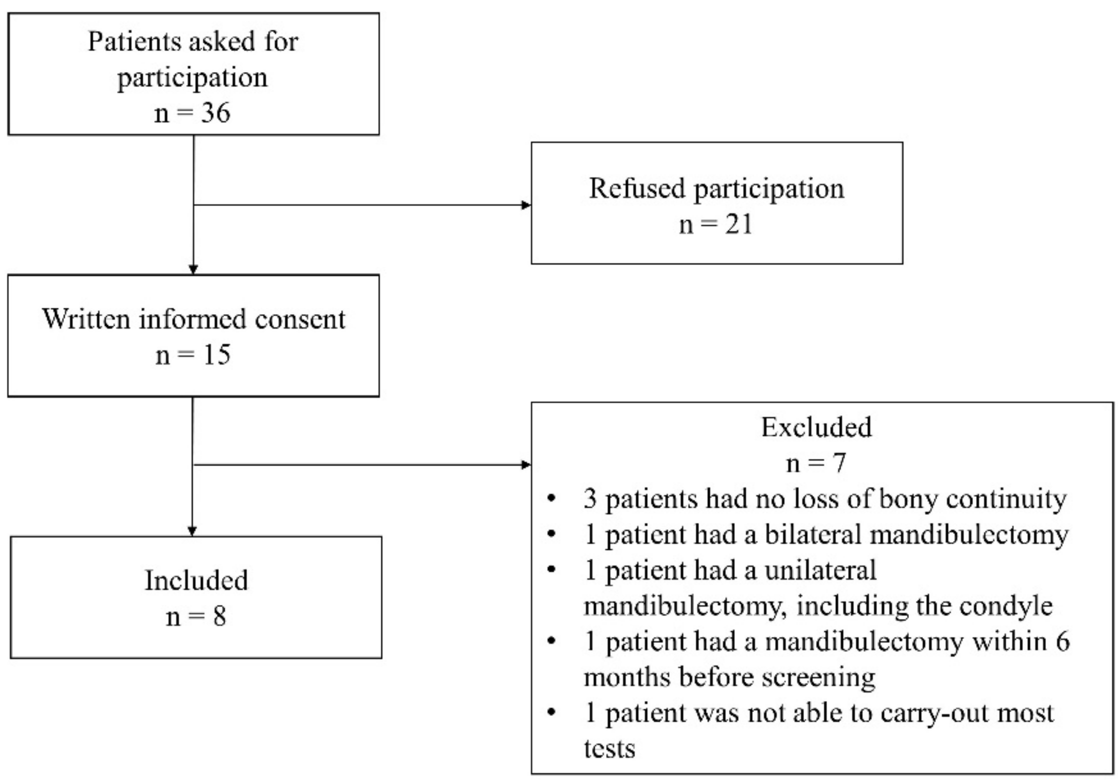


Figure 1: Flowchart inclusion.

Table 1: Patient characteristics, bite function and OHIP scores.

Nr.	Gender	Age (Years)	Reconstruction type	Brown classification	Occluding pairs	Total occlusal force: Posterior operation side (N)	Total occlusal force: Posterior non-operation side (N)
1	M	61	DCIA-flap	II	Extremely shortened	/	201.0
2	F	79	DCIA-flap	II	Extremely shortened	0.0	0
3	M	67	DCIA-flap	I	Moderately shortened	253.0	770.0
4	M	78	Free Fibula Flap	II	Moderately shortened	139.0	152.0
5	M	74	DCIA-flap	I	Moderately shortened	72.0	195.0
6	M	87	Free Fibula Flap	I	Moderately shortened	/	228.0
7	F	67	Free Fibula Flap	II	Slightly shortened	101.0	196.0
8	F	33	DCIA-flap	I	Slightly shortened	228.0	392.0

Nr.	M. Masseter Force: operation (N)	M. Masseter Force: non-operation (N)	Lips Force (N)	Tongue Force (N)	Tongue- and jaw-function: operation side (%)	Tongue- and jaw-function: non-operation side (%)
1	0.5	1.4	5.8	0.1	97,3	96,5
2	0.2	0.8	0.9	1.1	20,5	58
3	1.4	2.5	7.3	3.8	91,1	72
4	0.6	1.4	3.4	2.2	0,6	55,3
5	0.4	0.5	1.9	1.8	34	71,9
6	0.4	1.0	3.6	2.6	95,3	54,8
7	1.6	1.5	2.9	0.1	69,6	16,1
8	1.9	1.7	2.6	2.7	/	/

Nr.	OHIP-1	OHIP-2	OHIP-3	OHIP-4	OHIP-5	OHIP-6	OHIP-7	OHIP-8	OHIP-9	OHIP-10	OHIP-11	OHIP-12	OHIP-13	OHIP-14	Total OHIP
1	1	5	2	2	1	1	1	1	1	2	2	1	2	1	23
2	3	4	2	5	4	4	1	1	2	3	1	3	1	2	36
3	2	1	1	4	1	1	1	5	1	5	2	1	1	1	27
4	1	1	1	1	2	1	1	1	1	1	2	1	1	1	16
5	1	1	5	4	4	5	4	3	4	3	4	5	4	4	51
6	1	1	2	5	1	4	3	1	3	3	1	5	4	3	37
7	4	1	1	5	1	1	1	1	1	1	1	1	1	1	21
8	1	3	3	2	1	1	1	1	1	1	3	5	1	2	26

Note: DCIA: Deep Circumflex Iliac Artery Bone Flap

Objective assessment of the bite function

Comparison between operated and non-operated side: The average total occlusal bite force on the operated side was 50% reduced, compared to the non-operated side. Similarly, the average contraction force of the masseter muscle on the operated side was 35% lower compared to the non-operated side. However, a minimal difference of 3% was observed for average tongue and jaw function.

Influence of the number of occluding pairs: For patients with an extremely shortened dental arch, the total occlusal bite force was either physically unmeasurable or below the measurable threshold of the Digital Occlusal Force Meter GM10. Among those with moderately shortened dental arches, the mean total occlusal bite force was 155.0 ± 92.0 N, while for slightly shortened dental arches, it was 165.0 ± 90.0 N. Notably, the average contraction force of the masseter muscle was lowest for patients with extremely shortened dental arches (0.4 ± 0.2 N), followed by those with moderately shortened dental arches (0.7 ± 0.5 N) and slightly shortened dental arches (1.8 ± 0.2 N).

Remarkable differences in lip compression were observed among patients with extremely shortened dental arches, resulting in a mean of 3.4 ± 3.5 N. In contrast, for patients with moderately and slightly shortened dental arches, the mean lip compression was 4.1 ± 2.3 N and 2.8 ± 0.2 N, respectively. Regarding tongue extension force, patients with extremely shortened dental arches exhibited the lowest average force (0.6 ± 0.7 N), followed by those with slightly (1.4 ± 1.8 N) and moderately (2.6 ± 0.9 N) shortened dental arches, respectively. Notably, there was high variability within the groups for tongue and jaw function, with 58.9

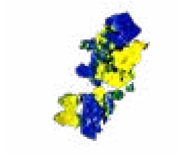
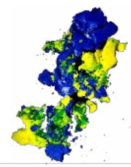
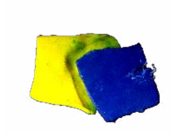
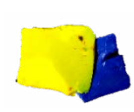
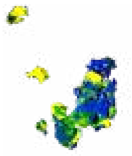
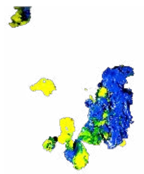
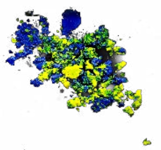
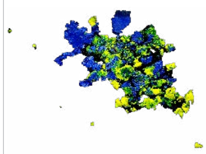
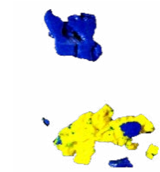
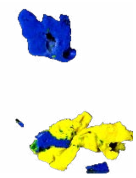
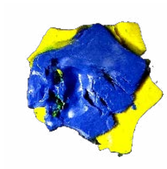
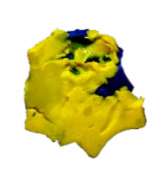
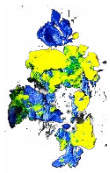
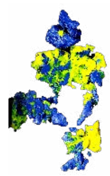
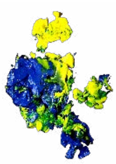
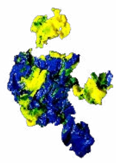
± 54.3% for the extremely shortened dental arch group and 55.3 ± 45.9% for the moderately shortened dental arch group. Additionally, only 1 patient in the slightly shortened dental arch group was able to perform the peanut test, resulting in a reported value of 69.6%.

Bite efficiency: Table 2 presents the visual analysis conducted by two different examiners (E.D. and L.V.L.) and the unmixed ratio. The Cohen's kappa statistic indicated a moderate agreement (K = 0.571) between the examiners. All analyzed samples were classified as SA3 or lower (Table 2).

Subjective assessment of the bite function

The mean overall OHIP-score was the lowest for the slightly shortened dental arch (24 ± 4) compared to the ones of the extremely (30 ± 9) and moderately (33 ± 15) shortened dental arch groups. The mean overall OHIP-scores over all patients was 30 ± 11. The highest scores were rated for OHIP-4 (physical pain) and

Table 2: Bite efficiency analysis.

Nr.	$SA_{side\ a}$ (1)	$SA_{side\ a}$ (2)	$Photo_{side\ a}$	$SA_{side\ b}$ (1)	$SA_{side\ b}$ (2)	$Photo_{side\ b}$	Total OHIP
1	SA 2	SA 2		SA 3	SA3		23
2	SA 1	SA 1		SA 1	SA1		36
3	SA 3	SA 3		SA 3	SA2		27
4	SA 3	SA 3		SA 3	SA3		16
5	SA 2	SA 1		SA 2	SA1		51
6	SA 1	SA 1		SA 1	SA1		37
7	SA 3	SA 2		SA 3	SA2		21
8	SA 3	SA 3		SA 3	SA3		26

Note: SA1: chewing gum not mixed, impressions of cusps or folded once; SA2: large parts of chewing gum unmixed; SA3: bolus slightly mixed, but bits of unmixed original color; SA4: bolus well mixed, but color not uniform; SA5: bolus perfectly mixed with uniform color

OHIP-10 (psychological disability). A higher OHIP-score represents a lower OHRQoL.

Discussion

In modern medicine, patient experience is increasingly recognized as crucial, yet the predominant focus often remains on objective measurements for treatment planning and follow-up. However, both approaches may present limitations [19]. Therefore, the present study aimed to integrate both objective and subjective assessments to comprehensively investigate the implications of segmental unilateral mandibulectomy. Such surgical intervention can lead to functional limitations, including alterations in bite ability, with profound implications for patients' future well-being [2,4]. Within this framework, outcomes between the operated and non-operated sides were compared, including the impact of dental arch length.

Initially, the objective assessment revealed that patients undergoing segmental mandibular resection exhibited approximately half the occlusal bite force on the mandibulectomy side compared to the non-mandibulectomy side. Additionally, a decrease in masseter muscle force was noted on the mandibulectomy side. These findings align with those of Ihara and colleagues [20], who similarly observed lower occlusal bite and masseter muscle forces on the non-operated side, with statistical significance noted only for the masseter muscle force. Conversely, Linsen and colleagues [21] reported a statistically significant difference in occlusal bite force measurements. Despite this, only a marginal 3% difference was detected in average tongue and jaw function between the operated and non-operated sides, a trend underscored by Curtis and colleagues [5], who demonstrated the negative impact of mandibulectomy on tongue and jaw function, regardless of reconstruction. Moreover, Curtis and colleagues emphasized the substantial influence of mandibular resection location, revealing a significant correlation between tongue function and bite ability.

Furthermore, individuals with a slightly shortened dental arch exhibited greater masseter muscle contraction force and overall occlusal bite force compared to those with moderately and extremely shortened arches. This underscores the significance of dental rehabilitation in enhancing bite strength and, consequently, improving bite comfort. Similar conclusions drawn by Van der Bilt, et al. [24] emphasize the detrimental impact of a shortened dental arch on bite function, highlighting the pivotal role of both the number of dental elements and bite force. This pattern was not observed for lip and tongue forces. Likewise, the outcomes of the mixed peanuts test did neither align with this trend, despite the importance of tongue movements as a parameter in bite assessment [6].

In evaluating bite efficiency, the visual inspection of chewed wax revealed a moderate agreement between observers (κ = 0.571), consistent with the findings of Schimmel and colleagues [7]. While this study did not yield statistical significance, de Groot and colleagues [25] demonstrated a significant influence of the number of occluding pairs on bite efficiency. Namaki and colleagues [2] also reported a significant decrease in bite efficiency following mandibulectomy.

Secondly, our patient population's subjective OHIP-14 score, at 30 points, is three times higher than the score reported for the general elderly by Ikebe and colleagues [26]. This disparity suggests a significant impact of mandibulectomy on patients' OHRQoL. Additionally, our findings indicate a worse overall OHIP score among those with a shorter dental arch. This aligns with the findings of Tan and colleagues [27], who reported a correlation between a shortened dental arch and the severity of OHIP-14.

Overall, there exists a strong correspondence between objective and subjective assessments. The diminished bite forces observed in the patient population, when compared to a healthy reference, are paralleled by lower patient-reported Oral Health-Related Quality of Life (OHRQoL). Additionally, the link between a shortened dental arch and reduced bite forces is mirrored in lower OHIP-14 scores. As highlighted by Namaki and colleagues [2], pain influences bite behavior, often resulting in a preference for easily chewable foods. Consistently, the OHIP-14 results pinpointed pain as a prominent issue within the OHRQoL of the patient population, aligning with the observed decrease in bite forces. Notably, it is noteworthy that individual patients experiencing the most severe pain are not necessarily those with the poorest bite outcomes. Furthermore, psychological discomfort was markedly impacted, as also noted by Dholam and colleagues [28]. However, while an association between psychological discomfort and decreased bite function is suggested in the literature, it cannot be definitively concluded from our study population.

While this study highlights a potential impact of segmental unilateral mandibulectomy on both objective and subjective bite forces, several limitations warrant consideration. Firstly, the study's sample size is relatively small, which is understandable given the rare prevalence of the specific surgical procedure and the strict inclusion criteria. Although these criteria ensure a homogeneous sample, limited to cases of segmental unilateral mandibulectomy without dental rehabilitation, they inherently precluded statistical analysis and reduced the generalizability of the findings. Secondly, some missing data occurred due to patient-specific circumstances (pain during biting or tongue hypersensitivity). Although these cases slightly reduced the number of available measurements, the reasons for missingness were unrelated to the patients' general oral function or reconstructive characteristics, and the impact on the interpretation of results is therefore considered limited. Thirdly, the measurement of tongue and jaw function consistently commenced on the non-operated side, potentially biasing results by providing patients with more familiarity and readiness for the subsequent measurement on the surgical side. To mitigate this, it would be preferable to conduct this test at two distinct time points, administered by different observers, thus eliminating any potential bias favoring the operating side during the second measurement. However, organizing such a protocol is challenging within a study population comprising patients recovering from intensive cancer treatments. Fourthly, although specific validation of the GM10 and OMFT devices in post-mandibulectomy patients is lacking, both instruments have been validated in related populations and were used here with calibrated, standardized protocols. This likely mitigates the potential impact of measurement error and strengthens the reliability of the recorded outcomes. Fifthly, only the masseter muscle was directly assessed. Masseter function serves as a robust reference point for masticatory performance, yet the temporalis and pterygoids also play important roles. Practical constraints precluded their evaluation. However, overall occlusal bite force was measured with the GM10 device, which reflects the combined action of all masticatory muscles and partly compensates for this limitation. Finally, patients with dental rehabilitation were excluded to ensure a homogeneous study population and to assess the effects of segmental unilateral mandibulectomy without confounding influences. As a result, the findings are most applicable to non-rehabilitated patients and may not be fully generalizable to the broader population, in which rehabilitation often plays a significant role. Future research including rehabilitated patients is therefore warranted.

By examining the impact of mandibulectomy through force and efficiency measurements alongside patient-reported questionnaires, this study offered a comprehensive perspective on the objective and subjective aspects of the associated challenges. By integrating both, patients can develop more informed expectations regarding the functional outcomes following mandibulectomy. Additionally, our findings underscored the utility of the OMFT Measuring Station 430 and Digital Occlusal Force-Meter GM10 in a clinical context.

In conclusion, segmental unilateral mandibulectomy significantly impairs patients' bite function. Notably, bite force and efficiency are notably diminished on the side of the mandibulectomy, with a more pronounced reduction observed in cases of a shorter dental arch. These objective deteriorations align with alterations noted in subjective patient assessments. It is important to note that this study serves as an initial indication of these trends, highlighting the need for further research to draw more definitive conclusions.

Declarations of Interest

None.

Author Contributions

Conceptualization; Robin Willaert and Véronique Christiaens. Data curation; Lina Van Lint and Jeroen Van Dessel. Formal analysis; Lina Van Lint and Jeroen Van Dessel. Investigation; Lina Van Lint, Fleur Van den Bergh, Emma Dierick, Laurens Verdonk and Lynn Christiaens. Methodology; Véronique Christiaens. Project administration; Robin Willaert. Resources; Lynn Christiaens and Peter Helderop. Supervision; Véronique Christiaens. Validation; Lina Van Lint, Fleur Van den Bergh and Emma Dierick. Visualization; Lina Van Lint. Roles/Writing - original draft; Lina Van Lint. and Writing - review & editing; Laurens Verdonk, Jeroen Van Dessel, Robin Willaert, Michel Bila and Véronique Christiaens.

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Data Statement

Data supporting the findings of this study are available from the corresponding author upon reasonable request.

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