# Differences in motoric function of masticatory and facial muscles post segmental mandibulectomy and hemimandibulectomy

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## ABSTRACT

**Introduction:** The highest predilection for jaw tumors is located in the mandible. One of the management of tumors in the mandible is resection. The resection will result in a discontinuity in the jaw and disruption of the stomatognathic system, one of which is a decrease in the motoric function of the masticatory muscles. Electroneuromyography (ENMG) is a type of examination that includes an electroneurography (ENG) examination, which includes a Neural Conduction Study (NCS) based on stimulation value (STIM) and velocity (VEL), and electromyography (EMG) which can be used to assess motoric function impairment of masticatory and facial muscles in patients undergoing mandibular resection. This study analyzed the differences in the motoric function of masticatory and facial muscles post-segmental mandibulectomy and hemimandibulectomy. **Methods:** This preliminary analytical cross-sectional study compares ten post-segmental mandibulectomy or hemimandibulectomy patients who had undergone mandibular reconstruction in the Oral Surgery Department of Hasan Sadikin Hospital Bandung. Assessment was performed using an AO plate (Arbeitsgemeinschaft für Osteosynthesisfragen) towards the patients. The results were compared using Chi-Square and Mann-Whitney statistical analysis. **Results:** A decrease in masticatory muscle function was detected using ENMG. NCS and EMG assessments were obtained. There was no significant difference in NCS values ($p>0.05$) in patients with segmental mandibulectomy (mean STIM 4.2 ± 1.7, VEL 13.23 ± 5.38) and hemimandibulectomy (mean STIM 4.3 ± 1.35, VEL 12.56 ± 4.83), however, a significant difference was found in the EMG values ($p=0.025$; $p<0.05$) of the patients with segmental mandibulectomy (mean 70% of patients were normal) and hemimandibulectomy (mean 20% of patients were normal). **Conclusion:** There are differences in the decreased motoric function of masticatory and facial muscles post-segmental mandibulectomy and hemimandibulectomy.

**Keywords:** motoric function; masticatory muscles; facial muscles; mandibular resection

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## INTRODUCTION

Tumor is common known and no longer an unfamiliar disease over the public.[1] Tumor or also known as neoplasm is a group of abnormal cells as a result of an abnormal growth of lump that constantly expanding infinitely, disharmonized with its surrounding tissue, and thriveless for the body. In the stomatognathic system, tumor or neoplasm is defined as an abnormal tissue growth inside the oral cavity which has an uncontrolled growth and has no use over the body. Mandibular tumor is one of the most common odontogenic tumor with high incidence.[2,3,4]

Mandibular tumors can be divided into benign tumors such as ameloblastoma, ameloblastic fibroma, odontogenic keratocyst, and malignant tumors such as squamous cell carcinoma, osteosarcoma, and adenocarcinoma.[3,4,5] The treatment of this disease requires multidisciplinary collaboration and support from various parties, including doctors, dentists, nurses , and all health workers.[6]

Mandibular resection is the first-line treatment for mouth and neck tumors. Mandibular resection is the removal of all of the mandibular or some part of its bone in order to prevent tumor recurrence.[7] There are four types of resection that are commonly performed in cases of mandibular tumors; marginal mandibulectomy, segmental mandibulectomy, hemimandibulectomy, and total mandibulectomy. The main difference between the four types of resection is the number or the large area of mandibular bones resected. There are several factors that will influence the decision of the oral surgeon to perform the bone resection, including tumor invasion of the mandibular bone, the depth of soft tissue invasion, the size of the tumor in the soft tissue, whether the tooth is located or not, and the depth of bone invasion (measured in mm).[8]

The two most common types of resection in cases of mandibular tumors are segmental mandibulectomy and hemimandibulectomy. Segmental mandibulectomy is the removal of part of the mandibular bone where mandibular bone continuity is not maintained. Hemimandibulectomy is a mandibular resection procedure that involves one side of the mandible, including the condyle, coronoid process, angulus and part of the mandibular body.[8,9,10] The procedure is performed under general anesthesia and using both extraoral and intraoral approach.

Motoric function is a function of harmony that involves muscle strength and movement, gross motor movement, fine motor skills and motor planning.[11] Muscles are attached to bones in the area of origin and insertion.[12] Origo is the end part of a muscle that is attached to the bone with a steady or stable movement at the time of contraction (the tendons in the bones are immovable). The insertion is the tip of the muscle that is attached to the bone, and will change its position when there is a contraction (the tendon in the bone that can be moved).[13,14] Insertion is the end part of the muscle that is attached to the bone, and its position will be changed when there is a contraction (the tendon in the movable bone) .[13,14] With the reduction or disappearance of the bone where the muscle is attached, either at the origin or the insertion, the motoric function of the masticatory muscles and the facial muscles around the mandible are disrupted.

The extent of bone removal during mandibular resection may influence the changes in motoric function of the masticatory muscles and facial muscles. Loss of mandibular can impair the motoric function of masticatory and facial muscles around the mandibular area. Appropriate resection should be chosen to minimalize impairments due to the treatment to maintain patient's quality of life, especially towards patients in low-middle income settings.

The study of the electrophysiological activity of skeletal muscles in rest and contraction with electromyography (EMG) and nerve impulse conduction along the peripheral nerves with the Nerve Conduction Study (NCS), has become a very useful diagnostic test for the assessment of motor muscle function, which can be used in patients who undergo mandibular resection.[11,12] Mandibular resection is a treatment that is indicated for a presence of benign tumor, infections, and osteonecrosis.

However, recent studies concluded that mandibular resections impair the masticatory process and facial expression of patients after surgery. The aim of the study was to analyse the differences in motoric function of the masticatory muscles and facial muscles in

patients who had segmental mandibulectomy and hemimandibulectomy based on the Neural Conduction Study (NCS) and Electromyography (EMG).

## METHODS

A preliminary analytical cross-sectional study was conducted to compare ten patients with benign ameloblastoma after segmental mandibulectomy or hemimandibulectomy who had undergone mandibular reconstruction with an AO *(Arbeitsgemeinschaft für Osteosynthesefragen)* plate in the Oral Surgery Department of Hasan Sadikin Hospital, Bandung during the research period. The sample size was determined using a formula for hypothesis test using the coefficient ***r*** with calculations according to the theory by Hosmer and Lemeshow. The decrease in masticatory muscle function was detected through electroneuromyography, and the results of Nerve Conduction Studies (NCS) and electromyography (EMG) were assessed.

The ENMG examination room was a separate room with 20-23°C temperature, the patient was prepared so that the examined muscle area would be clearly visible. The operator had to clean the examined area, apply abrasive gel and clean it with gauze. Attach the stimulator according to the location of the examined nerve with a distance of 10-14 cm from the active electrode, the sensory nerve action potential (SNAP) image then appears on the computer and NCS data can be noted. EMG examination was performed by pricking the examined muscle with an EMG needle while viewing the insertion activity on a computer. In this study, the examined muscles were musculus nasalis, musculus orbicularis oris, and musculus masseter. Research was conducted after the subject or family was provided with information and voluntarily participates in the research, followed by an informed consent. The research was conducted after obtaining approval from the Health Research Ethics Committee of the Central General Hospital (RSUP) dr. Hasan Sadikin Bandung with the approval number of 646/UN6/KEP/EC/2019. Results were compared using Chi-Square and Mann-Whitney statistical analysis.

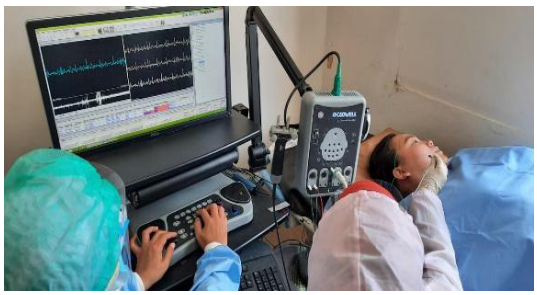

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**Figure 1 and 2. Illustration of EMG and NCS Assessment in ENMG examination room**

## RESULTS

The characteristics of respondents based on sex in the hemimandibulectomy group were mostly female with as many as 7 respondents (70.0%), while the male was 3 respondents (30.0%). In the segmental mandibulectomy group, the majority were female with as many as 6 respondents (60.0%), while male respondents was 4.

Table 2 presented the the motoric function of the masticatory muscles, which were based on Nerve Conduction Studies (NCS), and shown by the STIM and Vel values. In the hemimandibulectomy group, the STIM value that did not show the normal point (<4.5) was the left facial motor oris

**Table 1. Patients characteristic**

| Characteristic | Groups | | p-value |
|---|---|---|---|
| | Hemi-mandibulectomy | Segmental resection | |
| Sex | | | |
| Male | 3 (30.0%) | 4 (40.0%) | 0.639 |
| Female | 7 (70.0%) | 6 (60.0%) | |
| Age | | | |
| ≤ 25 | 6 (60.0%) | 4 (40.0%) | 0.706 |
| 26-35 | 2 (20.0%) | 2 (20.0%) | |
| 36-45 | 1 (10.0%) | 1 (10.0%) | |
| >45 | 1 (10.0%) | 1 (10.0%) | |
| Body Height | 158.6 ±5.4 | 157.1 ±9.3 | 0.761 |
| Body Weight | 58.7 ±12.5 | 51.5 ±10.9 | 0.226 |

Table 2. NCS test result

| NCS | Groups | | Normal Point | p-value |
|---|---|---|---|---|
| | Hemimandibulectomy | Segmental Resection | | |
| **STIM** | | | | |
| Nasalis motor left facial | 3.8±0.7 | 3.9±1.6 | <4.5 | 0.543 |
| Nasalis motor Right facial | 3.5±0.9 | 4.1±1.6 | <4.5 | 0.343 |
| Oris Motor Left Facial | 5.4±2.0 | 4.5±1.7 | <4.5 | 0.364 |
| Oris Motor Right Facial | 4.5±1.8 | 4.6±2.2 | <4.5 | 0.940 |
| **VEL** | | | | |
| Nasalis motor left facial | 15.2±2.8 | 14.6±4.6 | >45 | 0.849 |
| Nasalis motor Right facial | 15.0±4.2 | 15.0±3.6 | >45 | 0.970 |
| Oris Motor Left Facial | 11.4±8.8 | 10.8±4.2 | >45 | 0.674 |
| Oris Motor Right Facial | 8.7±3.5 | 13.3±9.1 | >45 | 0.208 |

with a value of 5.4 ± 2.0, while the VEL value that showed the normal point (> 45) did not exist. In the segmental mandibulectomy group, the STIM value that was not included in the normal point (<4.5) was the Oris Motor Right Facial with a value of 4.6 ± 2.2, while all VEL values did not show the normal point.

In the case of hemimandibulectomy patients, observed from the motor service of the masticatory muscles using EMG calculations, a decrease was showed in the left orbic oris facial, right orbic oris facial, left trigeminal masseter and right trigeminal masseter. Whereas, in the case of segmental mandibulectomy, there was a decrease in the right orbic oris facial, left trigeminal masseter and right trigeminal masseter.

While Table 3 presented the results of the motoric function of the masticatory muscles and facial muscles was based on the EMG indicator. In the hemimandibulectomy group, the normal EMG was only found in 20% respondents, while 80% were abnormal. Meanwhile, patients with segmental mandibulectomy showed a normal EMG of 70% and only 30% abnormal. There was a significant difference in EMG values ($p=0.025$, $p<0.05$) in patients with segmental mandibulectomy (mean 70% of patients are normal) and hemimandibulectomy (mean 20% of patients are normal).

Table 3. EMG test result

| EMG | Groups | | p-value |
|---|---|---|---|
| | Hemimandibulectomy | Segmental resection | |
| Normal | 2 (20.0%) | 7 (70.0%) | 0.025 |
| Abnormal | 8 (80.0%) | 3 (30.0%) | |

## DISCUSSION

Motoric function is a function of harmony that involves muscle strength and movement, gross motor movement, fine motor movement and motor planning.[12] The motoric function of the masticatory muscles can be measured through electroneuromyography (ENMG). ENMG examination is a combination of electroneurography (ENG) and electromyography (EMG) examination. ENG examination is also called a nerve conduction examination, one of which is the Nerve Conduction Study (NCS) assessment which includes the examination of muscle motor stimulation and velocity.[15,16] A proper assessment of motoric function of the masticatory muscles and facial muscles through ENMG examination in patients who have undergone different types of mandibular resection is important as a basis for selecting the type of mandibular resection. Muscles can lose >50% of their volume when the motor nerve is transected. Furthermore, the long term denervation of skeletal muscle results in a reduction in both the number of muscle fibers and the muscle diameter, and there is a subsequent atrophy of the muscle. Kauhanen et al reported that by 9 months after motor nerve resection during free flap transplantation, there was a 40% reduction in the diameter of muscle fibers.[17]

The most commonly performed mandibular resection procedures are segmental mandibulectomy and hemimandibulectomy. The main difference between the two procedures is the amount of mandibular bone resected. There are several factors that will influence the oral surgeon's decision to perform bone resection,

including tumor invasion of the mandibular bone, the depth of soft tissue invasion, the size of the tumor in the soft tissue, whether the tooth is located or not, and the depth of bone invasion (measured in mm).[17]

There is no significant difference of NCS value at both resection procedures which proofs that both procedures had succeeded in maintaining the nerves around the resection area. In the hemimandibulectomy group, STIM value that did not show the normal point (<4.5) was at the left facial motor oris with a value of 5.4 ± 2.0, while a normal point of VEL value (> 45) was not found. In the segmental mandibulectomy group, the STIM value that was not included in the normal point (<4.5) was the Oris Motor Right Facial with a value of 4.6 ± 2.2, while all VEL values did not show at the normal point. These results indicate stimulation disturbances that are common in both resection procedures in the left and right oris muscles. similar to Manfuso et al reported in 2020.[18]

In 2020, Elsayed reported decrease of facial muscle motor function after facial surgery that includes nerve resection. Meanwhile, we found a significant difference between the two resection mandibulectomy. The more bone is reduced, the more muscle attachments are lost, resulting in less motoric function of the masticatory muscles and facial muscles in that area, especially the masseter and orbicularis oris muscles.[18,19]

In a hemimandibulectomy, the angle and ramus of the mandible are removed which result in the loss of insertion of the masseter muscle on one side of the jaw. This event will decrease the motoric function of these muscles in moving the mandible which causes reduced masticatory function and disruption of lower facial expressions. Reconstructive action has proven that it is impossible to completely restore muscle motoric function.[17] Therefore, mature consideration in choosing the appropriate type of mandibular resection needs to be applied to minimize losses that will affect the patient's quality of life. Similar studies comparing the procedures ($p < 0.05$) in the EMG examination. In the case of hemimandibulectomy patients, we saw a decrease of motoric function in the left and right orbic oris facial, as well as both left and right trigeminal masseter muscles. Whereas, in the case of segmental mandibulectomy, there was a motoric function decrease in the right orbic oris facial, left and right trigeminal masseter muscles. Based on the two resection cases, we concluded that the masseter and orbicularis oris muscles experienced motoric problems.[19]

Table 3 shows that the hemimandibulectomy group only has 20% normal EMG, while 80% were abnormal. Furthermore, patients with segmental mandibulectomy showed a normal EMG of 70% and only 30% abnormal. This showed the number of resected bones affects the motoric function of the muscles attached to the bone. The hemimandibulectomy procedure involves a greater reduction of the mandibular bone compared to the segmental mandibulectomy. The more bone is reduced, the more muscle attachments are lost, resulting in less motoric function of the masticatory muscles and facial muscles in that area, especially the masseter and orbicularis oris muscles. [18,19]

Reduction in motor muscle function after segmental resection and hemimandibulectomy, especially in Indonesia as a low-middle income country,have not been published yet. Recent study that examined the decrease in motoric function of the masticatory muscles and facial muscles after mandibular resection was described in a studyby Vijayaraghavan et al.[19] who examined the decrease in muscle function based on ENMG in patients after mandibular marginal resection. The results of the study by Vijayaraghavan et al. showed that there was a decrease in masseter and temporalis muscle function in patients undergoingmandibular marginal resection.

Limitations exist in this study in terms of including only two variations of mandibular resection types since segmental mandibulectomy and hemimandibulectomy were found most frequent in Indonesia, especially in the Oral Surgery Department of Hasan Sadikin Hospital, Bandung. Further research regarding the motoric function of masticatory and facial muscles can include marginal and total mandibulectomy as variables. Factors regarding patient's characteristics are weakly included as contributors of the results. So, further research can reveal whether sex, age, genetics, personal lifestyle, and other social determinants support or inhibit the difference in the motoric function of masticatory and facial

muscles after mandibular resection. Suggestions for further research may also be assessing the temporomandibular joint function of patients after mandibular resection.

There is a significant decrease in the motoric function of masticatory and facial muscles around the mandibular area post segmental mandibulectomy and hemimandibulectomy based on the results of the electromyography (EMG) assessment in the two groups of patients. The decrease was found higher in the hemimandibulectomy group of patients, specifically in the motoric function of masseter masticatory and orbicularis oris facial muscles.

## CONCLUSION

There are differences decrease motoric function of masticatory and facial muscles post segmental mandibulectomy and hemimandibulectomy.

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