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Evaluation of Mandibular Movements in Patients with Bell's Palsy Using Kinematic Variables

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Abstract

Background: Since the function of muscles, and subsequently the mandibular joint, is affected in patients with Bell's palsy, therefore, the evaluation of facial muscles and mandibular function in these patients can be effective in diagnosis, prevention, and treatment planning. The present study aimed to evaluate the degree of displacement and range of motion (ROM) of the mandible and the ability of the facial symmetrical muscles of patients with Bell's palsy.

Methods: This was a quasi-experimental comparative study. The variables evaluated were mandibular movement in a vertical direction and side-to-side displacement. Ten patients with Bell's palsy and 10 healthy eligible volunteers participated in the present study. Three mobile video cameras (to record jaw movements), 9 color markers, Kinovea software, House-Brackmann index, Toledo protocol, and a specialized patient questionnaire were used. Descriptive and inferential statistics were used for data analysis, the Kolmogorov-Smirnov test was used to investigate the normality of data distribution, and independent samples the t test and paired samples t test were used to compare means.

Results: The maximum lateral on the sound side was 12.40 and 4.49 mm during lateral movements of the patients' mandible, while this value was between 12.30 and 3 mm on the involved side. There is a difference between the affected side and the nonaffected side in terms of the mean lateral movements of the patients' mandible. However, this difference in the mean ROM on both sides is not statistically significant. The maximum mouth opening in healthy individuals during mandibular movements was between 40 and 60 mm, while this value was between 25 and 50 mm in the patients with Bell's palsy. This study shows a significant difference ($P = 0.007$) between patients and healthy individuals in terms of the mean of maximum mouth opening ($P < 0.05$).

Conclusion: The results of this study showed that the ROM of temporomandibular joint (TMJ) of the patient is the same as that of normal subjects, but the side-to-side motion is more than normal which should be considered in rehabilitation treatments. The present study emphasizes the need to implement a mandibular kinematic evaluation protocol in patients with bell's palsy to prevent damage to the TMJ in the long term.

Keywords: Bell's Palsy, Mandibular Movements, Facial Muscles, Kinematic Variable

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Introduction

Bell's palsy is a type of facial paralysis that results from paralysis of the seventh cranial–or facial nerve and is referred to as peripheral nerve disease. The main function of the nerve is the innervation of muscles such as the digastric and stylohyoid in the motor part and also the stapedius muscle in the middle ear and providing parasympathetic instructions to the salivary and lacrimal parotid glands (1). This disorder may occur at any age, and gender does not

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↑What is "already known" in this topic:
Hitherto, Bell's palsy has been investigated from different aspects: diagnosis, complications, treatment, et cetera. Previous researches show the evaluation of the mandibular range of motion is not the treatment priority in examining the disease and is focused on solving Bell's palsy's appearance problems.

→What this article adds:
In addition to introducing a new system for evaluating the kinematic variables of the mandibular movements, the results of this study showed that the range of motion of TMJ of the patient is the same as that of normal participants, but the side-to-side motion is more than normal that should be considered in rehabilitation treatments.

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affect the number of people with this disorder (2, 3).

Facial nerve palsy may be due to basal cranial injuries, congenital syndromes, tumors, diabetes, viral infections and inflammation and pressure on the facial nerve and chronic middle ear infection, hypertension, neurological disorders and stroke, Lyme disease, surgical lesions, paralysis due to accidents and animal bites, sharp objects, axonal damage, or damage to the motor pattern in the cerebral cortex (4). Also, any lesion or damage that occurs in the brainstem to the terminal branches of the seventh facial nerve can cause rupture or paralysis of the facial nerve (5, 6).

Patients with facial paralysis usually complain of weakness or complete paralysis of the muscles on one side of the face. The disease complications include facial asymmetry, difficulty in closing the eyes completely, dryness and burning eyes, drooping corner of the mouth and damage to half of the smiling muscles, which is one of the most important facial movements (7), uncontrollable drooling, difficulty swallowing, weakness of the facial muscles, muscle strain, and synkinesis (8).

To deal with the disease complications with a prevention, reduction, and improvement approach, invasive treatments such as surgery (9) and noninvasive treatments, such as muscle strengthening with exercise and massage (10, 11), ultrasound, hot pack and heating methods, magnet protocol, laser treatment and Kabat rehabilitation (12), electrical stimulation (13), drug control, biofeedback (14) and physiotherapy techniques (15), faradic and galvanic current, acupuncture (16), and Botox have been used (17-20).

According to a thorough examination of the relevant study literature, the majority of studies on muscular abnormalities in the temporal, eyes, cheeks, and lips were conducted despite investigations into various elements of bell's palsy (outside the joint) (21-25), and the bell's palsy complications on the intracapsular temporomandibular joint as a challenging issue was not investigated comprehensively.

Also, previous studies have investigated the extent of jaw ROM in various diseases with impaired facial motor symmetry, but because bell's palsy is a neuromuscular disease, it is not directly included in the group of TMJ diseases. There are few studies on the evaluation of jaw movements of patients with bell's palsy using kinematic variables, and it does not seem to be a research or even therapeutic priority.

Therefore, there is a need for pertinent, thorough investigations because there are no conclusive solutions to the problem of reduced ROM brought on by muscular dysfunction, which causes the mandibular movements of bell's palsy patients to be asymmetric. The present study aimed to investigate the asymmetry in the patient's mandibular movements and to evaluate the reasons for the decrease in their mandibular ROM compared with the displacement rate of a healthy mandible using kinematic variables.

Methods

This was a quasi-experimental comparative study. The number of 10 people was calculated using G*Power software (Heinrich Heine University Düsseldorf, Germany) with a statistical powerof =0.88, effect size of 0.7, and P < 0.05 (using Cohen's criterion). Also, 25 people whose Bell's palsy was confirmed by a neurologist were referred to the rehabilitation center of Shiraz University of Medical Sciences with a referral letter. As the available population, 10 volunteer Bell's palsy patients who met the criteria for entering the study, were selected purposefully. According to the number and age of the Bell's palsy patient group, 10 healthy people were considered.

The inclusion criteria for people with Bell's palsy were as follows: (1) medical diagnosis of peripheral facial paralysis, without surgery to regenerate the facial nerve; (2) no facial or cervical trauma and surgery in the past; (3) no partial or full dental dentures; (4) obtaining a score between 4 and 11 in the protocol of clinical evaluation of facial movements for Bell's palsy (26). The inclusion criteria for healthy participants were as follows: (1) no complaint or medical diagnosis of facial paralysis; (2) no history of trauma to the face or surgery on the face or neck; (3) no use of partial or full dentures; (4) obtaining a score of 19 to 20 in the clinical evaluation protocol of facial mimic (26).

Data Collection Instruments

Three standard mobile camcorders, 3 fixed camera stands, an adjustable short chair, 9 color markers (14 mm in diameter), Kinovea software, and the House-Brackmann (HB) index are all commonly used tools for measuring the lateral movement of the corner of the mouth and the upper movement of the upper eyebrow in order to create the HB index, which is used to classify the level and severity of facial nerve damage (27–29) and measure the extent of Bell's injury. Data collection instruments included the Toledo facial paralysis clinical assessment protocol (30), the complementary protocol of mandibular movement values, a specialized questionnaire related to specific conditions of Bell's palsy, a general health questionnaire, participants' demographic characteristics, and consent form.

System Set-up

Unlike current business systems, an innovative method of motion capture system has been proposed in this study, which includes 3 simple video mobile phone cameras (able to record 100 frames per second) that record 120-second videos of mandibular movements and facial symmetry of patients and healthy people. The cameras were mounted on fixed bases from 3 directions, right, left, at a 90-degree angle, at a distance of 50 cm, and very close to the patient (Figure 1a). Nine color markers with a diameter of 14 mm were placed on both sides of the face (maxillary-temporomandibular joint) (mandibular angle) (middle area between the chin and the mandibular angle) for showing anatomical points to increase mandibular movement (forehead, upper lip, chin) (Figure 1b). After collecting information with 3 cameras, Kinovea line and tracking software were used to analyze data related to the amount of displacement and ROM of the jaw (31). Validity, reliability, and sensitivity tests of the system showed an average error of 0.156 and an accuracy of 0.259 mm for the measured displacements in the sagittal and frontal plates to record mandibular movement.

Following the patient's referral to the rehabilitation center, the participant sat on a normal adjustable chair with

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a b

Figure 1. Cameras (a) color markers (b) adjusting and preparing the system for recording facial symmetry and mandibular movements with three mobile cameras.

their feet on the floor and leaned their head against the wall. Each person was given the necessary training before data recording. The cameras were placed at a minimum distance of about 50 cm, and all 3 cameras formed a complete 90° angle with the other cameras and the patients' face. These 3 cameras only filmed the person's face. Nine markers with a diameter of 14 mm were placed on the faces of the patients to increase the visibility of mandibular movement, without affecting the data collection (31).

Data Collection

To perform a clinical evaluation of symmetry in movements and the ability of facial muscles, the Toledo protocol was used, which was analyzed in terms of function-beautification of both sides of the face under different voluntary states.

By observing participants as they spontaneously blinked, spoke, and smiled, we were able to investigate involuntary movements related to the sense of feeling on each side of the face. These movements included eyebrow-raising, eyelid movements when opening and closing the eyes separately and simultaneously, upper lip rising through a frowning nose, diagonal stretching of the upper lip to smile, horizontal stretching of the upper lip and revealing the lower teeth, as well as involuntary movements related to the sense of feeling on each side of the face. Scores 0 and 1 and indicate no disorder, decreasing evaluation, and normal state, respectively. Lip and eyelid deformity at rest, and the presence of synkinesis or hypertension were measured using negative values, that is, 0, -1, and -2 that indicate no deformity, partial or mild deformity, general or severe deformity, respectively. Final scores can range from -6 to 20 points for each side based on the partial value of the obtained values (30).

International parameters of temporomandibular joint examination (maximum opening of the mouth, maximum lateralization of the mandible to the right and left, mandibular protrusion) were followed to assess the degree of displacement and mandible movements (2).

Mandibular Displacement and ROM

Midline: While the teeth are occluded, it is investigated whether the lines between the upper and lower central incisors are in the same line. We measured the deviation from the midline when they did not match (Measuring the distance of one line horizontally from another line) (Figure 2a).

Maximum Mouth Opening: Measuring the distance between the edges of the upper and lower teeth (Figure 2b).

Figure 2. Mandibular displacement and range of motion in patients and healthy participants.
Lines between upper and lower central incisors b. Maximum mouth opening.

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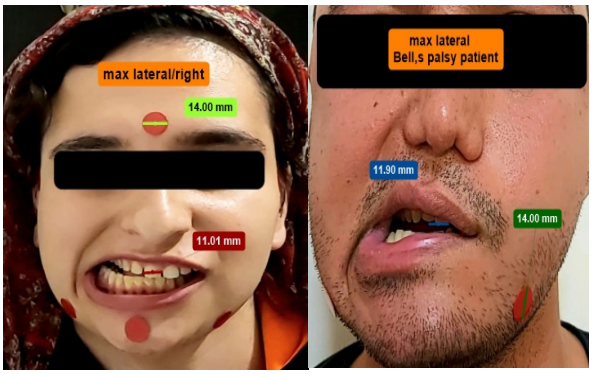

Figure 3. Maximum lateral movement of the mandible in the patient and healthy groups.

Figure 4. Protrusion of the patient and healthy subject

Maximum Lateralization of the Mandible to the Right/ Left: Measuring the horizontal distance of the line between the lower central incisors and the line between the upper central incisors after the mandible displacement to the right/ left. Relevant settings were used when there was a midline deviation (Figure 3).

Maximum mandibular protrusion: Measurement of protrusion and maximum horizontal change of the mandible (Figure 4).

Statistical Methods

The mean, standard deviation, minimum and maximum values by using software SPSS 20 were used to describe the data, and for inferential analysis of the data, the Kolmogorov-Smirnov test was used to check the normality of data distribution, and independent and paired samples t tests were used for comparison between normal and Bell's palsy groups.

To measure the validity and reliability of our results, we used a gold standard system for comparison. The reliability and validity of the results were excellent. Maximal mouth opening, involvement, sound side, and protrusive movements all had correlations of 0.98, 0.75, 0.98, and 0.96, respectively, according to Pearson correlation coefficient. The intraclass correlation coefficient confirmed the strong internal correlation between the 2 variables (mobile camera and motion analysis systems), which is 0.98, 0.81, 0.96, and 0.97 for the above 4 movements, respectively.

Results

The participants with idiopathic bell's palsy included 3 men and 7 women (a mean and standard deviation of age 41 ± 19 years). Among the participants, 7 were affected on the left side of the face while three were affected on the right side (the mean and standard deviation of weight, 58 ± 11 kg). The patients suffer from this disease between 2 to 4 years. (The mean and standard deviation, 2.7 ± 0.7 years).

A total of 70% of the patients were women (3 men and 7 women) (the mean and standard deviation, 5 ± 2). The results of using the Toledo evaluation protocol in the first part of the study show that 98% of patients had involuntary movements and incomplete opening and closing of the eyes during voluntary activities. A total of 95% of the participants complained of crooked lips when laughing. Almost all patients suffered from asymmetrical faces and subsequent aesthetic problems, and also the disease complications were not among their treatment priorities. left-side bell's palsy was observed in 70% of cases.

In the second part of the study, mean, standard deviation, minimum and maximum, and statistical results related to comparing the range of mandibular movements (maximum mouth opening, maximum lateralization of the mandible to the right and left, maximum mandibular protrusion) in patients with bell's palsy and healthy participants are presented in Table 1.

As shown in Table 1 to investigate the normal distribution and to evaluate the extent of mandibular displacement of the patient on the side affected by bell's palsy with the nonaffected side, descriptive statistics were used. Considering the normal distribution and thus the statistically significant difference between the means of the 2 groups in terms of the change of patients' mandible to the side affected by bell's palsy with the nonaffected side, regardless of the right or left side. The maximum lateral on the sound side was 12.40 and 4.49 mm during lateral movements of the patients' mandible, while this value was between 12.30

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Table 1. Statistical results of normal tests and comparison of mean and standard deviation displacement and range of motion of mandible in different cases between bell's patients and healthy individuals and involved and sound sides

Variable	Group	Minimum	Maximum	level of Kolmogorov-Smirnov test	Mean ± SD	*P*- values
right/ left _Lateral	(involved side) patient	3	12.30	0.821	8.21±3.03	0.030
right/ left _Lateral	(sound side) Patient	4.94	12.40	0.973	8.52 ± 2.82	
Max- Protrusion	healthy	5.01	8.22	0.930	6.88 ±1.58	0.14
	patient	4.01	8.65	0.694	6.85 ± 1.35	
Max _Opening	healthy	42.02	59.41	0.771	49.49 ± 5.61	0.007*
	patient	25.01	50	0.940	40.31 ±7.74	

$P < 0.05$ Significant differences*

and 3 mm on the involved side. The paired t test was used to compare the mean difference between the 2 sides. There is a difference between the involved side and the sound side in terms of the mean lateral movements of patient's mandible. However, this difference in the mean ROM on both sides is not statistically significant.

Lateral movement of the mandible for both sides is between 5 to 13.5 mm in healthy individuals. The same movement displacement on the left and right sides of the patients' face was 3 to 12.30 and 4 to 13.50 mm, regardless of the affected side. The amount of mandibular protrusion was 4 to 8.22 and 4 to 8.65 mm in healthy individuals and patients, respectively, regardless of gender, age, and race. In mandibular movements, the maximum mouth opening in healthy individuals was between 40 and 60 mm, while it was between 25 and 50 mm in individuals with bell palsy.

Inferential data analysis was also performed by investigating normal distribution. According to the results of Table 1 and the Kolmogorov-Smirnov test, all variables had normal data distribution and the independent t test was used to compare the means of the variables. The results showed no significant difference between the mean of Left lateral and right lateral as well as the mean difference of max protrusion between the healthy and Bell's palsy groups. However, there is a significant difference between the healthy and Bell's palsy groups in terms of the mean max opening (Table 1).

Discussion

This study aimed to evaluate mandibular movements in patients with Bell's palsy and healthy individuals using kinematic variables.

The results of the study indicated lower values in terms of mandibular ROM (maximum mouth opening, maximum mandibular lateralization to the right and left, maximum mandibular protrusion and involved and sound side), in patients with Bell's palsy than normal individuals and motor limitations, and the temporomandibular dysfunction are visible in these patients (Table 1) (32). Inferential statistics showed a significant difference between the patient and normal groups in terms of the maximum mouth opening (Table 1).

Bell's palsy is a disease of the peripheral nerves that results from paralysis of the seventh cranial nerve or facial nerve (33). Facial nerve palsy occurs for a variety of reasons, and its subsequent lesions include corneal pain, impaired salivation, hearing impairment, facial weakness and asymmetry, difficulty closing the eyes completely, crooked corners of the mouth, and difficulty swallowing, and damage to half of the smiling muscles and synkinesis (34).

In bell's palsy, cranial nerve VII, is divided into 5 branches, including (1) temporal branch, (2) zygomatic branch, (3) buccal branch, (4) marginal mandibular branch, and (5) the cervical branch is damaged (35). According to the results of the Toledo protocol in the first part of the study, a high percentage of bell's palsy-induced injuries occurred to the muscles that were innervated by the first 3 temporal, zygomatic, and buccal branches of the cranial nerve VII. Any damage to these branches includes complications such as temporal paralysis, facial asymmetry, involuntary and incomplete movements in opening and closing the eyes during voluntary movements, and damage to the smiling muscles (36).

In this study, a significant difference was observed in the maximum mouth opening between the patient and normal groups. The cause of a significant reduction in maximal mouth opening in Bell's palsy can be investigated in the analysis of temporomandibular joint movements. We concluded that temporomandibular movements are performed by 4 main pairs of masticatory muscles, including the temporalis muscle, the masseter muscle, and the internal and external pterygoid muscle, and the digastric muscle (37). It is worth mentioning that masticatory muscles are innervated through the trigeminal cranial nerve with sensory and motor roots (38).

The digastric muscle is made up of 2 ventricles. The posterior ventricle of this muscle is innervated by the marginal mandibular branch of the seventh pair of the brain and its anterior ventricle by the trigeminal cranial nerve branches in the cranial nerve V (38).

When the 2 masticatory muscles of the temporalis and masseter, which function to raise and close the mouth and mandible, are at rest, the posterior ventricle of the digastric muscle and the platysma muscle (cervical skin), which are innervated by the fourth and fifth branches of cranial nerve VII, respectively, do the opposite action on the masticatory muscles and open the mandible. The results of inferential statistics demonstrate (Table 1) the cause of a significant decrease in the maximum mouth opening in Bell's palsy rationally and by citing the theoretical underpinnings of the aforementioned study, given that one of the complications of Bell's palsy is damage to the fourth and fifth branches of the cranial nerve vii and, consequently, dysfunction of the jaw-opening muscles (22).

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When Bell's palsy damages the marginal mandibular branch of the cranial nerve VII, the most deformity and asymmetry occurs in the face, but due to the combined behaviors of the mandible and the special features of the irregular muscles of the face, the patient can perform actions such as chewing, swallowing, and speech along with movement limitations and lack of proper functioning despite limited movement and muscle weakness (39) by reducing their activities and performing compensatory movements according to their unique conditions (40-42).

One of the complications of Bell's palsy is restriction in opening the mouth due to paralysis of the nerves that open the temporomandibular joint muscles in this disease. This complication may be due to unilateral chewing and consequent imbalance in muscle strength or a decrease in the mandibular ROM (43). This problem can be due to rotations and compensatory movements that are added to the end of the movements. The literature review shows that the issue of reduced mandibular ROM in patients with bell's palsy is not considered a challenging issue in the classification of specific mandibular diseases. Also, the statements of the patient's treatment process show that, usually, the protocol of kinematic evaluation of the mandible of the patient with Bell's palsy is not considered as a priority of functional tests by specialists (44).

Researching patients' treatment processes reveals that the patient, the therapist, and even most specialists have not placed as much emphasis on treating the patient's appearance problems as they have on treating the patient's reduced mandibular ROM and unwanted extra movements during its displacement. However, this asymmetry and reduction of mandibular ROM, in the long run, will cause complications, such as gradual abrasion of the temporomandibular joint, tissue resorption around the teeth, and destruction of its enamel. Speech difficulty and the likelihood of various structural changes in the temporomandibular joint, such as disc deformity and joint pain, will also increase (45).

In this study, a mandibular kinematic evaluation system has been presented for the first time, in which a mobile phone is used as an affordable and accessible tool, with the approach of solving the evaluation problem with the expensive tools of specialized laboratories. Also, previous researches and the treatment process for Bell's palsy show that examining the amount of jaw displacement is not among the patient's treatment priorities. Considering that Bell's palsy affects the Jaw moving muscles, this research emphasizes the need to investigate ROM in patients with Bell's palsy to prevent side effects caused by excessive jaw movements.

As limitations of this study, we could mention that because Bell's palsy disease is rare, the number of available patients was limited. Only Bell Palsy patients who volunteered participated in this study and some patients did not want to cooperate. There was a lack of research background related to the side effects caused by the limitation of jaw ROM in Bell's palsy patients, and more scientific developments in this field were needed. In patients who need orthodontic treatment or whose jaw was noticeably more protruded, it was challenging to evaluate mandibular movements.

Conclusion

The results of this study showed that the ROM of TMJ of the patient (maximum mouth opening, maximum mandibular lateralization to the right and left, maximum mandibular protrusion, and involved and sound side) is the same as that of normal participants, but the side-to-side motion is more than normal, which should be considered in rehabilitation treatments. The present study emphasizes the need to implement a mandibular kinematic evaluation protocol in patients with bell's palsy to prevent damage to the temporomandibular joint in the long term .Thus, we should add TMJ function tests to the clinical assessment of bell's palsy.

Acknowledgments

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Ethical Considerations

After being informed about the research purpose and process, all participants signed and completed the consent form to participate in the study, which was accompanied by data collection protocols approved by the Committee for Ethics in Biomedical Research of Kharazmi University (IR.KHU.REC.1399.029).

Conflict of Interests

The authors declare that they have no competing interests.

References

1. Hughes SM, Aung T. Symmetry in motion: Perception of attractiveness changes with facial movement. J Nonverbal Behav. 2018 Sep;42(3):267-83.
2. Pinheiro AP, Pereira AA, Andrade AO, Bellomo D. Measurement of jaw motion: the proposal of a simple and accurate method. J Med Eng Technol . 2011 Apr 1;35(3-4):125-33.2.
3. Hadlock T. Facial paralysis: research and future directions. Facial Plast Surg. 2008 May;24(02):260-7.
4. Yonamine FK, Tuma J, Silva RF, Soares MC, Testa JR. Paralisia facial associada à otite média aguda. Rev Bras Otorrinolaringol. 2009;75:228-30.
5. Murthy JM, Saxena AB. Bell's palsy: Treatment guidelines. Ann Indian Acad Neurol. 2011 Jul;14(Suppl1):S70.
6. George E, Richie MB, Glastonbury CM. Facial nerve palsy: clinical practice and cognitive errors. Am J Med. 2020 Sep 1;133(9):1039-44.
7. Paraguassú GM, Sousa JA, Ferraz EG. Abordagem clínica e terapêutica da paralisia facial de Bell: uma revisão de literatura. Clínica e Pesquisa em Odontologia-UNITAU. 2011 Nov 24;3(1):45-9.
8. de Felício CM, Ferreira CL. Protocol of orofacial myofunctional evaluation with scores. Int J Pediatr Otorhinolaryngol. 2008 Mar 1;72(3):367-75.
9. Priya BS, Srinivasan KR, Lakshmanan P, Selvi P. Facial Nerve Injury Following TMJ Surgery and its Management by Electrical Stimulation–A Case Study. Biomed Pharmacol J. 2017 Dec 21;10(4):1855-61.
10. Li T, Ren J, Peng X. Therapeutic observation on superficial needling with different frequencies for intractable facial paralysis. J Acupunct. 2019 Dec;17(6):432-7
11. Pereira LM, Obara K, Dias JM, Menacho MO, Lavado EL, Cardoso JR. Facial exercise therapy for facial palsy: systematic review and meta-analysis.Clin Rehabil. 2011 Jul;25(7):649-58.
12. Barbara M, Antonini G, Vestri A, Volpini L, Monini S. Role of Kabat physical rehabilitation in Bell's palsy: a randomized trial. Acta Otolaryngol. 2010 Jan 1;130(1):167-72.
13. Kim J, Choi JY. The effect of subthreshold continuous electrical stimulation on the facial function of patients with Bell's palsy. Acta Otolaryngol. 2015 Sep 23.
14. Mirzakhani N, Oshnari LA, Baghban AA, Eliyspoor D, Javantash A,

[DOI: 10.47176/mjiri.37.19]

Kamalifar M, et al. The comparison between exercise therapy and biofeedback therapy in facial function and quality of life of Bell's palsy. J Physiother 2017;2(3):140-4.
15. Teixeira LJ, Valbuza JS, Prado GF. Physical therapy for Bell's palsy (idiopathic facial paralysis). Cochrane Database Syst Rev. 2011(12).
16. Fabrin S, Esposto DS, Milan MB, Zanella CA, Fioco EM, Regalo SC, et al. Acupuncture technique applied to the facial nerve branches in Bell's palsy. J Neurol Transl Neurosci. 2016;4:106.
17. Antunes JJ, Almeida SA, Monteiro RM, Martins AM. Idiopathic masseter muscle hypertrophy: a case report. Einstein (São Paulo). 2019 Mar 7;17.
18. Nilesh K, Dharamsi R, Patil P, Mate P. Management of unilateral idiopathic masseter muscle hypertrophy with botulinum toxin type A. BMJ Case Rep. 2021 Jan 1;14(1):e239056.
19. Yılmaz V, Aras B, Umay E. Temporomandibular joint dysfunction and impaired stomatognathic alignment: A problem beyond swallowing in patients with stroke. Indian J Otolaryngol. 2020 Sep;72(3):329-34.
20. Lassemi E, Sahraian MA, Motamedi MH, Valayi N, Moradi N, Lasemi R. Oral and facial manifestations of patients with multiple sclerosis. J Dent. 2014 Jan 1;4(2):1.
21. Lee CU, Yoo JH, Choi BH, Kim JB. The Care of Facial Palsy after Inferior Alveolar Nerve Block Anesthesia and Temporomandibular Joint Dislocation in Diabetic Mellitus Patient: A Case Report. Korean J Anesthesiol. 2011 Jun 1;11(1):45-50.
22. Kes VB, Cengić L, Cesarik M, Tomas AJ, Zavoreo I, Matovina LZ, et al. Quality of life in patients with multiple sclerosis. Acta Clin Croat. 2013 Mar 1;52(1):107-1.
23. Nguyen CN, Mallepally N, Tabilona JR, Lu LB. Not So Benign Bell's Palsy: Malignant Peripheral Nerve Sheath Tumor of the Facial Nerve Involving the Temporal Bone. J Gen Intern Med. 2021 Apr;36(4):1102-5.
24. Xie JJ, Washington NT, Chandran R. An unexpected souvenir: Lyme disease presenting as TMJ arthritis. Pediatrics. 2018 Apr;693-693.
25. Cui H, Zhong W, Yang Z, Cao X, Dai S, Huang X, et al. Comparison of Facial Muscle Activation Patterns Between Healthy and Bell's Palsy Subjects Using High-Density Surface Electromyography. Front Hum Neurosci. 2021 Jan 12;14:618985.
26. de Felício CM, Ferreira CL. Protocol of orofacial myofunctional evaluation with scores. Int J Pediatr Otorhinolaryngol. 2008 Mar 1;72(3):367-75.
27. Kanerva M, Poussa T, Pitkäranta A. Sunnybrook and House-Brackmann Facial Grading Systems: intrarater repeatability and interrater agreement. Otolaryngol Head Neck Surg. 2006 Dec;135(6):865-71.
28. Brackmann DE, Fisher LM, Hansen M, Halim A, Slattery WH. The effect of famciclovir on delayed facial paralysis after acoustic tumor resection. Laryngoscope. 2008 Sep;118(9):1617-20.
29. Coulson SE, Croxson GR, Adams RD, O'Dwyer NJ. Reliability of the "Sydney,""Sunnybrook," and "House Brackmann" facial grading systems to assess voluntary movement and synkinesis after facial nerve paralysis. Otolaryngol Head Neck Surg. 2005 Apr 1;132(4):543-9.
30. Toledo PN. Efeito da terapia miofuncional em pacientes com paralisia facial de longa duração associada à aplicação de toxina botulínica (Doctoral dissertation, Universidade de São Paulo). Sao Paulo Med J. 2007 Apr.
31. Puig-Diví A, Escalona-Marfil C, Padullés-Riu JM, Busquets A, Padulles-Chando X, Marcos-Ruiz D. Validity and reliability of the Kinovea program in obtaining angles and distances using coordinates in 4 perspectives. PLoS One . 2019 Jun 5;14(6):e0216448.
32. Sassi FC, Mangilli LD, Poluca MC, Bento RF, de Andrade CR. Mandibular range of motion in patients with idiopathic peripheral facial palsy. Braz J Otorhinolaryngol. 2011 Mar 1;77(2):237-44.
33. Demeco A, Marotta N, Moggio L, Pino I, Marinaro C, Barletta M, et al. Quantitative analysis of movements in facial nerve palsy with surface electromyography and kinematic analysis. J Electromyogr Kinesiol. 2021 Feb 1;56:102485.
34. Greco A, Gallo A, Fusconi M, Marinelli C, Macri GF, De Vincentiis M. Bell's palsy and autoimmunity. Autoimmun Rev. 2012 Dec 1;12(2):323-8.
35. The facial nerve, William H. Slattery, Babak Azizzadeh.thieme, 1st edition, 2014.
36. Hah YM, Kim SH, Jung J, Kim SS, Byun JY, Park MS, et al. Prognostic value of the blink reflex test in Bell's palsy and Ramsay-Hunt syndrome. Auris Nasus Larynx. 2018 Oct 1;45(5):966-70.
37. Nigg BM. Biomechanics of the musculo-skeletal system. John Wiley & Sons Incorporated; 2007 Mar 12.
38. Felten DL, O'Banion MK, Maida MS. 9-Peripheral Nervous System. Netter's Atlas of Neuroscience, 3rd ed.; Elsevier sci: Amsterdam, The Netherlands. 2016:153-231.
39. Felício CM, Trawitzki LV, Marques AP, Fernandes FD, Ferreira VJ. Interfaces da medicina, odontologia e fonoaudiologia no complexo cérvico-craniofacial. J Craniofac Surg. 2009 Oct
40. Calil BC, da Cunha DV, Vieira MF, de Oliveira Andrade A, Furtado DA, Bellomo Junior DP, et al. Identification of arthropathy and myopathy of the temporomandibular syndrome by biomechanical facial features. Biomed Eng Online. 2020 Dec;19(1):1-8.
41. VanderWerf F, Reits D, Smit AE, Metselaar M. Blink recovery in patients with Bell's palsy: a neurophysiological and behavioral longitudinal study. Investig Ophthalmol Vis Sci. 2007 Jan 1;48(1):203-13.
42. Tuncay F, Borman P, Taser B, Ünlü I, Samim E. Role of electrical stimulation added to conventional therapy in patients with idiopathic facial (Bell) palsy. Am J Phys Med Rehabil. 2015 Mar 1;94(3):222-8.
43. Supriyana DS, Simadibrata C. Improved Iatrogenic Facial Nerve Paralysis Based on House–Brackmann Facial Nerve Grading System by Using Acupuncture Therapy: A Case Report. Med Acupunct. 2022 Mar 18.
44. Leissner O, Maulén-Yáñez M, Meeder-Bella W, León-Morales C, Vergara-Bruna E, González-Arriagada WA. Assessment of mandibular kinematics values and its relevance for the diagnosis of temporomandibular joint disorders. J Dent Sci. 2021 Jan 1;16(1):241-8.
45. Poveda Roda R, Díaz Fernández JM, Hernández Bazán S, Jiménez Soriano Y, Margaix Muñoz M, et al. A review of temporomandibular joint disease (TMJD). Part II: Clinical and radiological semiology. Med Oral Patol Oral Cir Bucal. 2008 Mar.

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