

# Effect of Stomatognathic Alignment Exercise on Temporomandibular Joint Function and Swallowing Function of Stroke Patients with Limited Mouth Opening

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**Abstract.** [Purpose] This study investigated the effects of stomatognathic alignment exercise on temporomandibular joint function and swallowing function of stroke patients presenting limited mouth opening. [Subjects] Fourteen subjects with post-stroke hemiparesis presenting limited mouth opening were randomly assigned to either the experimental group or the control group, with 7 subjects in each group. [Methods] Subjects in the experimental group participated in a stomatognathic alignment exercise program that consisted of mobility exercises of the TMJ and neck and postural correction. Main outcome measures were neck mobility, the active maximum range of mouth opening, the craniomandibular index (CMI), and the Mann assessment of swallowing ability (MASA) score. [Results] The changes in the values of the range of mouth opening, CMI, MASA, and all the parameters of neck mobility were significantly different between the groups. Furthermore, post-test values appeared to be significantly different for the range of mouth opening, the craniomandibular index, and the MASA scores between the groups ( $p > 0.05$ ). [Conclusion] Stomatognathic alignment exercise may improve TMJ function and swallowing function of patients with post-stroke hemiparesis.

**Key words:** Exercise therapy, Stroke, Temporomandibular joint

(This article was submitted Apr. 16, 2013, and was accepted May 29, 2013)

## INTRODUCTION

Approximately 50% of patients with post-stroke hemiparesis present with disabilities in facial control, and impairment of orofacial and mandibular functions is frequently involved. Clinical observation of stroke patients indicates they have greater variability and lower temporomandibular joint (TMJ) muscle activity on the affected side with a decreased bite force<sup>1)</sup>, representative of a reduction in TMJ function. Various functional tasks such as chewing, swallowing, and speaking are carried out by the coordinated action of the stomatognathic system, which includes skeletal and dental components, orofacial soft tissues, the TMJ, and the masticatory muscles<sup>2)</sup>. Functional adaptation of the TMJ may be essential to break down food into small pieces by chewing and swallow them, as it is involved in mouth opening and mastication during the initial stages of oral function. Swallowing abnormalities are often observed in patients who are recovering from stroke, and are likely to result in malnutrition and pulmonary complications<sup>3)</sup>.

Secondary changes in the early presentation of stroke

have been attributed to neurological and biomechanical changes including hypertonus, excessive muscular co-activation, muscle weakness, contracture, and increased muscle stiffness<sup>4)</sup>. Increased muscle tonus in the flexors of the neck and upper body could result in shortening of the flexors, which would further result in mechanical impairment of their actions, consequently altering body alignment and movement range. Furthermore, general symptoms of muscle weakness in patients after stroke can influence the postural alignment of the head and neck, resulting in asymmetrical positioning of their bodies due to postural changes and muscle shortening<sup>4)</sup>. Postural abnormalities may influence the mandibular position<sup>5)</sup>, which may lead to result in changes in proprioceptive and periodontal input, affecting movement patterns and postural stability<sup>6)</sup>. Postural and movement faults in the craniocervical regions and impairments in their control may be the primary reason for the decline in the function of the stomatognathic system, including the TMJ, and resultant swallowing problems<sup>7)</sup>. An apparent relationship between poorly aligned posture and TMJ dysfunction suggests that the initiation of active exercise to achieve postural correction is a valid treatment option for minimising these symptoms<sup>8)</sup>.

Although there are many therapeutic approaches for managing TMJ dysfunction, invasive methods cannot be

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used for stroke patients with poor health; therefore, conservative treatment should be considered first. Active exercises have been used alone and in combination with other treatments. Along with behavioural interventions (e.g., sensory stimulation of orofacial and pharyngeal structures, the use of modified food consistency, and postural changes to affect bolus flow)<sup>9</sup>, specific exercises to normalise the swallowing reflex, strengthening exercises for the orofacial and pharyngolaryngeal muscles<sup>10</sup>, active and passive range of motion exercises of the TMJ and neck, and postural correction exercises may be more appropriate for improving swallowing function. These exercises have also been commonly used as a therapeutic solution for the recovery of TMJ function<sup>11</sup>.

During the rehabilitation of stroke patients, it is important to consider TMJ function and swallowing function because of the negative impact of their impairment on the functional performance of daily activities. Thus, therapeutic knowledge about impairments in TMJ function and swallowing function are well known, and further research should focus on exploring specific treatment approaches that can be easily applied instead of elucidating the effects of the therapeutic methods previously reported. However, to our knowledge, data have not been published on the effectiveness of exercise therapy for improving TMJ and neck mobility and correcting postural alignment to promote TMJ function and swallowing function of hemiparetic stroke patients. In the present study, we investigated the effects of stomatognathic alignment exercise on TMJ function and swallowing function of stroke patients presenting limited mouth opening.

## SUBJECTS AND METHODS

Fourteen patients with post-stroke hemiparesis presenting decreased TMJ function were recruited for this study. Subjects were randomly assigned to an experimental group (EG) or a control group (CG). Inclusion criteria for this study were as follows: more than 6 months since stroke onset; decreased TMJ function ( $>0.13$  points on the craniomandibular index [CMI])<sup>12</sup> and limited range of mouth opening ( $<4.0$  cm)<sup>13</sup>; no orthopaedic or musculoskeletal conditions that would have interfered with the study results; and no cognitive impairment (a score  $>25$  in the Mini-Mental State Examination)<sup>14</sup>. Although 33 subjects volunteered to participate in this study, 17 subjects failed to meet the

inclusion criteria and 2 subjects (one in each group) were excluded from data analysis due to irregular participation in the experimental intervention and drop out following grouping. Prior to participation in the study, subjects were provided with a detailed description about all of the experimental procedures and their safety, and they signed a written informed consent form. The general characteristics of the subjects are summarised in Table 1.

We measured neck mobility (flexion, extension, rotation, and lateral flexion), TMJ function (mouth opening range and CMI), and swallowing function using the Mann assessment of swallowing ability (MASA) score. Measurements of neck mobility were performed using a tape measure (Hoechstmass, Sulzbach, Germany), with a modification of the method suggested by Norkin and White<sup>15</sup>. All measurements of neck mobility were performed with patients in a sitting position with back support. During the measurements, the head and neck were placed in the anatomical position, and the thoracic and lumbar spines were supported by a backrest. To avoid compensation through scapular and spinal motions, the subjects were asked to stabilise the shoulder girdle by holding the bottom of the chair. Neck flexion and extension were determined by measuring the distance between the suprasternal notch and the lower tip of the chin at maximal flexion and extension of the neck, respectively. The measurements of rotation and lateral flexion were performed on the affected side and the unaffected side, respectively, thus reflecting the restriction of cervical movement due to soft tissues in the neck region on the affected side. Neck rotation on the affected side was determined by measuring the distance between the tip of the chin and the suprasternal notch of the sternum at maximal neck rotation, and the lateral flexion of the neck on the unaffected side was measured using the distance between the acromion process and the mastoid process of the skull of the affected side at maximal lateral flexion of the neck. The values obtained from 3 trials were averaged to obtain the final value.

The range of mouth opening represents the interincisal distance<sup>16</sup> in the active maximum range, and can be measured using vernier calipers (Dial-15, Tajima, Tokyo, Japan) with a precision of 0.01 cm. TMJ function was assessed using the CMI, which consists of the dysfunction index (DI), which evaluates the extent of TMJ dysfunction and the palpation index (PI), which evaluates the tenderness severity of the orofacial and neck muscles. The total CMI score is

**Table 1.** General characteristics of subjects

	EG	CG
Gender (male / female)	5 / 2	5 / 2
Age	53.71 ± 12.46	56.14 ± 12.31
Onset duration (months)	43.00 ± 27.90	13.57 ± 16.53
Stroke type (hemorrhage / infarction)	5 / 2	4 / 3
Paretic side (right / left)	4 / 3	5 / 2
MBI	47.14 ± 15.90	48.14 ± 19.87
MMSE-K	22.86 ± 5.43	21.14 ± 5.90

EG, experimental group; CG, control group; MBI, modified Barthel index; MMSE-K, mini-mental state examination-Korean version

the sum of the DI and PI scores divided by 2. The scores of all 3 indices range from 0 to 1, and a high score indicates a greater dysfunction in the TMJ and the surrounding muscles. The CMI shows good inter-rater and intra-rater reliabilities<sup>13</sup>. In addition, swallowing function was assessed using the MASA, which is a comprehensive clinical assessment of dysphagia in a bedside setting<sup>17, 18</sup>. The MASA has 24 clinical items that assess oral sensory and motor aspects of swallowing, cooperation and auditory comprehension, tongue function, and functional assessment of swallowing. Each item is scored according to severity, and swallowing impairment is determined by a composite score out of a total of 200. A higher score indicates better swallowing function. The MASA has been found to be valid and reliable for the assessment of patients with post-stroke hemiparesis<sup>2</sup>.

Subjects were randomly assigned to either the EG or CG group. For randomization, they were asked to blindly draw a card from an envelope containing 2 cards. All subjects received a daily 1-hour functional training in their routine rehabilitation schedule, which consisted of mat exercise and therapist-guided practice of functional activities, such as sit-to-stand exercise and stepping to reinforce normal movement pattern. In addition, the subjects in the EG group participated in the stomatognathic alignment exercise program, with an average duration of 1 hour, three times a week for 4 weeks (12 sessions in total). The outcome measurements were performed before and after the 4-week training. The stomatognathic alignment exercise program consisted of exercises to increase the mobility of the neck and TMJ (active range of motion [ROM] exercises for the neck and TMJ) and to correct head and neck posture (chin tuck exercise and anterior chest stretching exercise), as recommended by Oh et al<sup>11</sup>. In the chin tuck exercise, the chin was pulled backwards over the upper part of the sternum to position the patient's ears in line with the tips of the shoulders. This was repeated 10 times with a 10-second hold in supine, and 5 times with a 2-minute hold in standing against a wall. In the anterior chest stretching exercise, the head and shoulder blades were pressed back against a wall while maintaining the chin tuck position and standing against the wall with a straight back; the arms were maintained at 45° shoulder abduction, with the elbows fully extended and the forearms supinated. This exercise was performed 10 times with a 10-second hold. In the active ROM exercises for the neck and TMJ, flexion, extension, and lateral flexion and rotation of the neck were performed on the affected and unaffected sides, followed by maximal mouth opening, protrusion, and lateral excursion on the sides for the TMJ while sitting on a chair with a backrest. These exercises were performed with a 10-second hold at the end of the range of motion for each motion, with 2 sets of 10 repetitions performed for each motion.

Data were analysed using SPSS 12.0 (SPSS Inc., Chicago, IL, USA). All values are expressed as medians and inter-quartile ranges. Because our sample size was small, we used non-parametric analysis in order to determine the effects of the exercise program on TMJ function and swallowing function of patients with post-stroke hemiparesis. Within-group and between-group comparisons were per-

formed using the Mann-Whitney U test and the Wilcoxon signed-rank test, respectively. The significance level for identifying statistical differences was chosen as 0.05.

## RESULTS

The values of neck mobility (flexion, extension, rotation, and lateral flexion), the range of mouth opening, and the CMI and MASA scores of the EG and CG, as well as the change in each variable, are listed in Tables 2 and 3. Patients in the EG showed significant differences between pre- and post-test values in all measures of neck mobility (flexion:  $z = -2.20$ ,  $p = 0.03$ ; extension:  $z = -2.37$ ,  $p = 0.02$ ; rotation:  $z = -2.37$ ,  $p = 0.02$ ; and lateral flexion:  $z = -2.37$ ,  $p = 0.02$ ), whereas no significant differences were noted for any of the measures in the CG (flexion:  $z = -1.84$ ,  $p = 0.07$ ; extension:  $z = -0.84$ ,  $p = 0.40$ ; rotation:  $z = -1.19$ ,  $p = 0.23$ ; and lateral flexion:  $z = -0.14$ ,  $p = 0.89$ ). Significant differences in the change in the values (between pre- and post-test) were observed for all measures between the EG and CG (flexion:  $z = -2.07$ ,  $p = 0.04$ ; extension:  $z = -3.08$ ,  $p < 0.01$ ; rotation:  $z = -2.89$ ,  $p < 0.01$ ; and lateral flexion:  $z = -2.69$ ,  $p = 0.01$ ). In the EG, significant pre- to post-test differences were noted in the range of mouth opening ( $z = -2.37$ ,  $p = 0.02$ ) and the CMI ( $z = -2.37$ ,  $p = 0.02$ ) and MASA ( $z = -2.37$ ,  $p = 0.02$ ) scores, whereas no significant differences were noted for any of the measures in the CG (the range of mouth opening:  $z = -0.31$ ,  $p = 0.75$ ; CMI:  $z = -0.45$ ,  $p = 0.65$ ; and MASA:  $z = -1.63$ ,  $p = 0.10$ ). In addition, post-test values appeared to be significantly different for the range of mouth opening and the CMI and MASA scores between the EG and CG (the range of mouth opening:  $z = -2.75$ ,  $p = 0.01$ ; CMI:  $z = -3.03$ ,  $p < 0.01$ ; and MASA:  $z = -2.11$ ,  $p = 0.03$ ). The change in the value between pre- and post-test differed significantly for the range of mouth opening ( $z = -2.11$ ,  $p = 0.03$ ), and the CMI ( $z = -3.21$ ,  $p < 0.01$ ) and MASA ( $z = -3.17$ ,  $p < 0.01$ ) scores between the two groups.

## DISCUSSION

To our knowledge, this is the first study to investigate the effect of exercise therapy on both TMJ dysfunction and swallowing problems of post-stroke patients. This study was designed to elucidate an easy and appropriate treatment approach for TMJ dysfunction and swallowing disorders by eliminating possible factors that induce these symptoms. Our findings demonstrate that stomatognathic alignment exercise may be beneficially used to improve TMJ function and swallowing function of patients with post-stroke hemiparesis.

Clinical observations indicate that many patients with post-stroke hemiparesis generally have poor posture. Their sitting postures are typically characterized formed by a backward pelvic tilt, flexed trunk, and forward head position with a tendency of lateral trunk flexion and lateral pelvic tilt with consequent asymmetrical weight bearing on the buttocks<sup>19</sup>. Forward head posture results from the shortening of the posterior neck muscles (including the suboccipital, splenii, semispinalis, and upper trapezius muscles) and the sternocleidomastoid muscles<sup>20</sup>. Muscular and ligamentary connections of the TMJ with the cervical region form

**Table 2.** Comparison of pre- and post-test neck mobility between the experimental and control groups

	EG	CG
Flexion		
pre-test	1.20 (0.30–2.30) <sup>a</sup>	0.20 (0.50–1.00)
post-test	0.00 (0.00–0.40)	0.10 (0.30–1.00)
difference*	–0.80 (–1.80– –0.30)	–0.10 (–0.20–0.00)
Extension		
pre-test	15.8 (15.2–18.5)	14.3 (15.4–17.6)
post-test	17.2 (16.5–19.5)	14.5 (15.2–17.5)
difference*	1.6 (1.0–2.0)	0.1 (–0.1–0.2)
Rotation		
pre-test	12.3 (10.5–12.8)	10.40 (11.4–15.5)
post-test	12.6 (12.5–14.0)	10.20 (12.0–13.2)
difference*	1.5 (0.3–2.0)	–0.20 (–0.3–0.1)
Lateral flexion		
pre-test	11.5 (11.0–12.5)	10.4 (11.50–14.0)
post-test	12.5 (12.1–13.5)	10.0 (11.50–14.3)
difference*	1.0 (0.3–1.3)	0.0 (–0.40–0.3)

<sup>a</sup>Median (inter-quartile range). EG, experimental group; CG, control group  
Significant differences between the groups are indicated by:  
\*, p<0.05

a functional complex in the craniocervical and mandibular regions, and postural abnormality in these regions is often associated with TMJ dysfunction. In the present study, the main focus of the stomatognathic alignment exercise included enhancement of the mobility of the neck and the TMJ, and restoration of postural alignment of the head and neck, with the aim of achieving functional improvement of the stomatognathic system.

We found that the range of mouth opening and the CMI score, which reflects TMJ function, appeared to be significantly improved after stomatognathic alignment exercise. Furthermore, the improved CMI score met the requirement for the average score of healthy individuals (i.e., >0.13 points on the CMI)<sup>12</sup>. These findings suggest that stomatognathic alignment exercise, with a focus on improving the flexibility of the TMJ and neck as well as postural correction, is essential for managing general symptoms of impaired TMJ function after stroke and can be used clinically. The effectiveness of exercise therapy is supported by previous studies that have investigated specific methods for treating individuals with TMJ dysfunction<sup>8, 11, 21</sup>.

TMJ dysfunction is reported to be strongly associated with a decrease in chewing function, which is probably a factor contributing to dysphagia and malnutrition, and has an important impact on the quality of life related to oral health of patients with post-stroke hemiparesis<sup>22</sup>. Limitations in TMJ and neck mobility may decrease the ability to chew by repetitive mandibular depression and elevation, and may negatively influence lingual mobility as well as anterosuperior movement of the hyoid<sup>23</sup>. This indicates the importance of mobility exercises for the TMJ and neck regions in the achievement of airway closure, for decrease of aspiration risk, by facilitating hyoid-laryngeal elevation.

**Table 3.** Comparison of pre- and post-test TMJ function and swallowing function between the experimental and control groups

	EG	CG
Mouth opening range		
pre-test	33.4 (31.5–35.4) <sup>a</sup>	25.2 (30.5–32.3)
post-test*	36.3 (32.5–40.1)	26.5 (30.3–32.3)
difference*	1.0 (0.9–3.5)	0.0 (–0.5–1.3)
CMI		
pre-test	0.24 (0.14–0.31)	0.16 (0.21–0.22)
post-test*	0.09 (0.09–0.15)	0.16 (0.21–0.24)
difference**	–0.12 (–0.15– –0.08)	0.00 (0.00–0.00)
MASA		
pre-test	163.0 (140.0–165.0)	146.0 (159.0–167.0)
post-test*	174.0 (164.0–183.0)	149.0 (159.0–167.0)
difference**	18.0 (9.0–22.0)	0.0 (0.0–2.0)

<sup>a</sup>Median (inter-quartile range)

EG, experimental group; CG, control group; CMI, craniomandibular index; MASA, Mann assessment of swallowing ability  
Significant differences between the groups are indicated by:  
\*, p<0.05 and \*\*, p<0.01

Therefore, it is important to encourage this type of exercise to improve orofacial and pharyngolaryngeal movements during swallowing by patients presenting TMJ and neck stiffness, enabling them to re-learn the use of the swallowing-related muscles<sup>24</sup>. In the present study, the MASA score for swallowing function was >170 points, which indicates the absence of aspiration risk<sup>18</sup>. This finding indicates that stomatognathic alignment exercise, which promotes TMJ and neck mobility and postural correction, can be used to improve swallowing function in a clinical setting. Previous studies have recognised the importance of muscular efforts in the pharyngolaryngeal regions and postural adjustment in maintaining a normal swallowing pattern after stroke<sup>2, 24</sup>.

Swallowing disorders that may develop after stroke can result in repeated aspiration and altered eating habits and patterns, which may subsequently contribute to an impaired physical condition, including the development of pneumonia, dehydration, and malnutrition<sup>3</sup>. Thus, swallowing disorders may increase the length of hospital stay and the risk of re-admission to hospital<sup>25</sup>. The initiation of therapeutic strategies aimed at preventing serious medical complications and ensuring safety in swallowing is essential in the treatment of post-stroke patients. During the swallowing process, the extrinsic muscles, such as the suprahyoid, infrahyoid, and sternocleidomastoid muscles, control vocal cord vibration and promote the contraction of the vocal cords, which then move forward on the larynx, thereby protecting the airway by laryngeal closure<sup>26</sup>. However, deviations in the head and neck posture alter the length-tension relationship of the intrinsic and extrinsic muscles that are located in the pharyngolaryngeal regions affecting control of the action of these muscles. Therefore, normalising the function of the pharyngolaryngeal muscles and maintaining appropriate muscular compliance should be performed

first to optimise swallowing function after stroke. Thus we attribute the improvement in TMJ function and swallowing function seen in the present study to the improved neck mobility.

Another explanation for our findings requires an understanding of the linkage between the muscular and fascial components and the influence of body posture on the function of the stomatognathic system including chewing and swallowing<sup>2)</sup>. The fascial system passively distributes tension, induced by mechanical stimulation, to the body muscles, and plays an important role in the effective transfer of tension induced by muscle contraction, which is essential for maintaining the contractile ability of muscles, suggesting that the actions of the muscles in the linkage can be mutually dependent, and may work as if they form a single system<sup>2)</sup>. The mechanisms underlying TMJ function and swallowing function may have a similar pattern, because orofacial and pharyngolaryngeal muscles of the stomatognathic system are closely related with muscle groups of the head and neck region. Moreover, impaired mobility of the extrinsic cervical muscles often disrupts the length-tension relationship of intrinsic pharyngolaryngeal and TMJ-related muscles, thereby reducing TMJ function and swallowing functions.

The present study had certain limitations. First, this study was a pilot trial with a small sample size; thus, it may be difficult to generalise the findings of this study beyond our group of patients. Second, the results of this study do not indicate the long-term effects of stomatognathic alignment exercise as the results of follow-up sessions were not included in the analysis. Finally, the present study aimed to evaluate TMJ function and swallowing functions, primarily focusing on clinical relevance (clinical assessment of the TMJ function and swallowing functions) rather than using specific equipment for quantitative measurements. Therefore, quantitative aspects of TMJ function and swallowing function are not reflected in the results of the present study. Nevertheless, this study describes a structured, exercise program for enhancing TMJ function and swallowing function that can be adopted for clinical use and is feasible for research use with larger sample sizes. However, the benefits of stomatognathic alignment exercise should be evaluated in greater detail in better designed clinical studies.

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