한국전문물리치료학회지 2019년 26권 3호 76-83
Phys Ther Korea 2019;26(3):76-83
ISSN (Print) 1225-8962, ISSN (Online) 2287-982X
https://doi.org/10.12674/ptk.2019.26.3.076

Reliability of Lateral Deviation Measurement in the Hyoid Bone With Center Point and Lateral Motion Tests

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Abstract

Background: The hyoid bone is the only non-jointed structure among the skeletal tissues of the head and neck region, and its movement and posture depend on the attached muscle, ligament, and fascia. The location of the hyoid bone is important for airway maintenance, vocalization, chewing, swallowing, breathing, and head and scapular position. In general, the location of the hyoid bone is measured using radiographs and 3D computed tomography, and no studies have reported on clinical measurement methods.
Objects: This study was performed to suggest clinical measurement methods for lateral deviation of the hyoid bone and to evaluate their reliability.
Methods: In this study, 24 healthy volunteers (12 males, 12 females) in Cheongju-si participated. Two examiners performed the center point test and lateral motion test twice each to measure the lateral displacement of the hyoid bone. The reliability of the center point test was analyzed using intra-class correlation coefficients (ICC), and the reliability of the lateral motion test was analyzed using Cohen's kappa coefficient.
Results: The intra-rater reliability of the center point test was good, and the inter-rater reliability was moderate. The intra- and inter-rater reliability of the lateral motion test showed substantial reliability.
Conclusion: Based on these results, the center point test and the lateral motion test can be used as an alternative methods of the measurement of lateral deviation of the hyoid bone for people who have musculoskeletal disorders of the head, neck, and scapula.

Key words: Clinical measurement method; Hyoid bone; Reliability.

Introduction

The hyoid bone is the only non-jointed structure among the skeletal tissues of the head and neck region, and it floats between the mandible and the thyroid cartilage. The suprahyoid and infrahyoid muscles attached to the hyoid bone maintain airway and swallowing maintenance, prevent reflux, and adjust the upright posture of the head (Park et al, 1998). At the age of three, the hyoid bone is located between the lower half of the third cervical vertebra and the upper half of the fourth cervical vertebra. It then moves downward to the fourth cervical vertebra as age increases (Bench, 1963).

Previous studies have reported that the alignment and function of the head, neck, jaw, and scapula are related to the position and movement of the hyoid bone. King (1952) found that the position of the head affects the position of the hyoid bone. According to his studies, the hyoid bone moves backward and upward when the head is extended, and moves forward and downward when the head is flexed. Oh et al. (1998) predicted that the soft tissues around the neck, hyoid bone, and tongue would be involved in the movement of the head and neck. Brodie (1950) mentioned the importance of the hyoid bone in the anterior and posterior equal tensions to balance the vertebrae in an upright posture. Bibby and Preston

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(1981) investigated how the suprahyoid muscles depress the mandible by contracting against a fixed hyoid platform, the absence of which may seriously impair mandibular opening. The hyoid bone has a affects not only the face, neck, and thorax but also the shoulder joints closely (Figueroa et al, 1991).

An inferiorly positioned hyoid bone has been implicated with decreased respiratory function because it is a common finding in patients suffering from obstructive sleep apnea (Gungor et al, 2013; Tsai et al, 2007). There also appears to be a decrease in movement of the hyoid in patients suffering from obstructive sleep apnea (Pae et al, 1994). Carreiro (2009) introduced a technique to induce hyoid bone stabilization by relaxing the omohyoid muscle in patient with oral pharyngeal dysfunction. Pettit and Auvenshine (2018) reported that resolution of myofascial pain was associated with relaxation of the suprahyoid musculature. Shih and Chuang (1998) confirmed fibrosis of the omohyoid muscle in patients with torticollis. When the anterior belly of the omohyoid muscle is shortened due to fibrosis, the hyoid bone is lowered to one side and the suprahyoid muscles are tensed, resulting in torticollis. When the omohyoid muscle is shortened, the balance between the upper trapezius and the lower trapezius is broken and the normal range of joint motion can not be secured (Bae et al, 2007). The omohyoid syndrome is the sudden onset of a severe muscle spasms on one side of the neck. The main symptoms are neck, shoulder and arm pain (Donatelli, 2011).

In general, the position of the hyoid bone is measured using radiographs, 3D computed tomography, and cone beam computed tomography, and its reliability is reported to be high (Pettit and Auvenshine, 2018). These measurements set the baseline, reference plane, and cephalometric points and measure the vertical position of the hyoid bone, the anterior and posterior positions, and the tilt. However, these measurements methods are not always recommended for all patients, as the cost is relatively expensive and a risk of exposure to radiation exists. Therefore, it is necessary to find test methods that are easy to use and less risky to human health to identify interval changes before and after physical therapy.

The purpose of this study was to propose a clinical measurement method of lateral deviation of the hyoid bone and to investigate intra- and inter-rater reliability level of this method. This study assumed that measurement of lateral deviation of the hyoid bone using the center point test and the lateral motion test would have more than moderate reliability.

Methods

Participants

This study was conducted on 24 healthy volunteers in Cheongju-si, who agreed to participate in this study. The general characteristics of the subjects are presented in Table 1. Subjects who had neurological or structural anomalies affecting the head and neck (such as forward head posture or head lateral deviation), severe neck pain that could not be tested, dysphagia, or orthodontic treatment were excluded from the study (Kim and McCullough, 2008). A sufficient explanation of the purpose and method of this study was provided to participants in advance, and voluntary consent was obtained to participate in this study. Two physical therapists who had more than 10 years of clinical experience working in a rehabilitation medicine clinic in Cheongju-si participated as inspectors. Before proceeding with this experiment, the examinee learned the measurement method and conducted a 30- minutes practice session for two days. This study was approved by the institutional review board of Cheongju University

Table 1. General characteristics of subject

	Male (n_1=12)	Female (n_2=12)
Age (years)	34.3±5.4[a]	26.5±4.0
Height (㎝)	175.3±3.8	158.6±3.2
Weight (㎏)	77.1±8.1	48.9±6.5
BMI[b]	25.1±2.3	19.5±2.5

[a]mean±standard deviations, [b]body mass index.

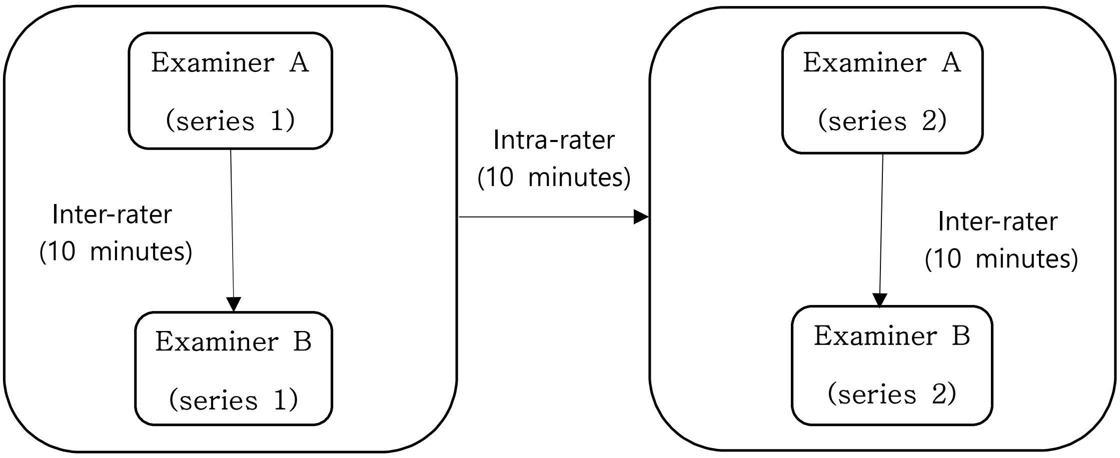

Figure 1. Study structure.

(approval number: 1041107-201812-HR-032-01).

Procedure

All experimental procedures were performed in an anatomical position, and the measurement posture was explained to the subjects before starting the experiment. To prevent movement during the measurement, the subjects were instructed to keep the initial posture as much as possible and not to move the mandible.

Two examiners performed measurements on the same subject, and the examiner blinded the results of the other examiners during the measurement. To evaluate the agreement between the examiners, examiner B measured 10 minutes after examiner A's measurement was completed. The inter-rater reliability was re-measured the same way 10 minutes after the first measurement of examiner B was completed (Figure 1). During the measurement, the subject did not complain about the difficulty or inconvenience of the measurement.

Measuring center point

The center point of the hyoid bone was measured using a tape measure (total length: 150 ㎝) with a 1-㎜ scale. To identify the baseline before identifying the lateral displacement of the hyoid bone, the examiner marked the neck's centerline connecting the mandible's center point and the jugular notch. The examiner then confirmed that the centerline matched the body's midline. The examiner stood facing the subject and palpated the superior thyroid notch and the hyoid bone that is 1 ㎝ above. Both index fingers moved outward along the hyoid body and palpated the greater cornua on both sides of the hyoid bone. After marking both sides of the larger cornua, the distance between the two points was measured, and the middle point was marked. The vertical distance from the center point of the hyoid bone to the centerline of the neck was measured using a tape measure to assess the deviation (Figure 2). The direction and distance of lateral deviation of the hyoid bone were recorded (on the right was +; on the left was -).

Measuring lateral motion

The examiner stood facing the subject and palpated the greater cornua on both sides of the hyoid bone in the same manner as when measuring enter point. Then, lateral motion was compared by pushing left and right alternately with both index fingers (Figure 3). When the hyoid bone moved similarly in both directions, it was recorded as center. When more motion occurred on either the right or left side, it was recorded as right or left.

Statistical Analysis

Intra-class correlation coefficients (ICC[2,1]), standard error of measurement (SEM; SD × $\sqrt{1-ICC}$),

Figure 2. Measuring center point.

Figure 3. Measuring lateral motion.

and 95% confidence interval (CI) were used to calculate the intra- and inter-rater reliability for the center point test. The ICC is an indicator used to assess repeatability and repeatability between examiners and is an estimate of the portion caused by inter-individual variability in the total variation of measures. ICC has a value between 0 (no match) and 1 (perfect match). The ICC values were interpreted according to Portney and Watkins (2009), who suggested that an ICC>.75 is good, an ICC from .50 to .75 is moderate, and an ICC<.50 shows poor reliability. However, no absolute criteria exist, and no correlation with the magnitude of error exists, so interpreting the ICC in terms of whether the error is acceptable is difficult.

Intra- and inter-rater reliability of the lateral motion test was determined by calculating Cohen's kappa coefficient, which are appropriate for nominal level data. The kappa coefficient is based on the percentage of agreement between repeated assessments that has been corrected for chance agreement. The kappa coefficient has a value between 0 and 1.0. Landis and Koch (1977) suggested the following guidelines for interpreting the strength of agreement using the kappa coefficients: <.00=poor; .00 to .20=slight; .21 to .40=fair; .41 to .60=moderate; .61 to .80=substantial; and .81 to 1.00=almost perfect agreement. When interpreted with the kappa coefficients, a value of 0 is considered approximately equal to chance agreement. Therefore, a score <0 indicates agreement that is less than chance agreement. The kappa modulus magnitude can be affected by a bias that reflects the dominance index, which reflects the occurrence rate of the attribute and the degree to which the evaluator does not agree on the proportion of positive (or negative) cases. Therefore, these factors should be considered when interpreting kappa values.

Results

Intra-rater and inter-rater reliability of the center point test

The intra-rater reliability of the center point test of the hyoid bone measured twice by examiner A was .899, which represented good. The SEM was .152. The inter-rater reliability of the center point test of the hyoid bone measured by examiners A

Table 2. Intra-rater and Inter-rater reliability of the center point test (N=24)

	ICC[a]	95% CI[b]	SEM[c] (㎝)
Intra-rater reliability	.899	.766～.956	.152
Inter-rater reliability	.635	.157～.842	.516

[a]intra-class correlation coefficients, [b]confidence interval, [c]standard error of measurement.

Table 3. Intra-rater and Inter-rater reliability of the lateral motion test (N=24)

		Rt[a]	Center	Lt[b]	Total	kappa	p-value
Intra-rater reliability	Rt	10	0	2	12	.768	<.001
	Center	0	1	0	1		
	Lt	1	0	10	11		
	Total	11	1	12	24		
Inter-rater reliability	Rt	8	1	2	11	.625	<.001
	Center	0	1	0	1		
	Lt	2	0	10	12		
	Total	10	2	12	24		

[a]right, [b]left.

and B was .635, which was moderate, and the SEM was .516 (Table 2).

Intra-rater and inter-rater reliability of the lateral motion test

The intra-rater reliability of the lateral motion test of the hyoid bone measured twice by examiner A was .768, indicating substantial reliability. The inter-rater reliability of the lateral motion test of the hyoid bone measured by examiners A and B was .625, indicating substantial reliability (Table 3).

Discussion

The purpose of this study was to propose a clinical measurement method of lateral deviation of the hyoid bone and to analyze its reliability. For this purpose, the lateral deviation of the hyoid bone was measured using the center point test and the lateral motion test. As a result, both the center point test and the lateral motion test showed more than moderate reliability.

This study was the first to attempt clinical measurement of the lateral deviation of the hyoid bone, so direct comparison with previous studies was difficult. Therefore, studies of other areas where lateral deviation was determined by the location of the center point were investigated. Diveta et al. (1990) determined the normal scapular abduction by measuring the distance between the spinous process of the third thoracic vertebrae and the inferior angle of the acromion. In this study, the intra-rater reliability of the scapular width measurements was .94, and the intra-rater reliability of the scapular abduction measures was .85. Fitzgerald and McClure (1995) determined the lateral displacement of the patella by palpating the medial and lateral femoral epicondyles and palpating the midpoint of the patella. If there was a difference between the medial distance and the lateral distance, this was considered as medial/lateral deviation. The intra-rater reliability of the method of determining the lateral displacement by measuring the center point in the patella was good (.83) (Herrington, 2008), but the inter-tester reliability varied.

In both the scapula and patella, the method of measuring the center point has proven to be clinically useful for identifying lateral deviation. In this study, the center point measurement of the hyoid bone in resting position showed a high level of intra-rater reliability and moderate inter-rater reliability. Since this study showed a good level of reliability, as in previous studies, the center point measurement of the hyoid bone was a clinically viable method.

The lateral motion test of the hyoid bone showed substantial intra- and inter-rater reliability. Studies that determined the lateral deviation of the object with a motion test were investigated. A lateral scapular slide test (LSST) exists to measure the asymmetry of the scapula. This method measures the distance between the spinous process of the eighth thoracic spine and the inferior angle of both scapula at 0, 45, and 90 degrees of shoulder flexion, respectively (Kibler, 1998). Gibson et al. (1995) reported a low reliability of LSST with an intra-rater reliability of .81 to .95 and inter-rater reliability of .18 to .69. On the other hand, in a study by Park et al. (2009), both the intra- and inter-rater reliability were high.

The patella glide test is performed with the knee flexed at 30 degrees; if the patella glides laterally over 75% of its width, a medial restraints laxity is diagnosed. When it glides less than 25%, lateral restraints tightness is predicted (Rossi et al, 2011). The inter-rater reliability of the patellar tendon mobility has been shown as -.27 to .56 (Sweitzer et al, 2010). Lateral/medial glide reached moderate to good inter-rater reliability (two out of five studies, k=.59 to .73) (Décary et al, 2016). The cause of this lateral dislocation in the patella is the medial patellar femoral ligament (Rossi et al, 2011). Since the motion test yielded reliable results in a number of studies, the lateral motion test used in the present study can be used to confirm the lateral deviation of the hyoid bone and is believed to be reliable.

The hyoid bone is closely related to the surrounding structures, and they are influenced by each other. The supra- and infrahyoid muscles depend on the hyoid bone to determine the curvature of the cervical spine and balance the craniovertebral joints (Rocabado, 1983). Hyoid kinematics has been related to diagnosis and treatment of neck disorder (Zheng et al, 2012), and hyoid position appears to be an indicator of the well-being of the musculoskeletal system of the head and neck (Pettit and Auvenshine, 2018). Despite the importance of the hyoid bone in maintaining the head, neck, and shoulder positions, study of the hyoid bone has been poor; it tends to be overlooked in the physical therapy. In addition, because of the need to rely on radiography or 3D computer imaging to measure the position of the hyoid bone, providing interventions related to the hyoid bone when applying physical therapy has been difficult. Most studies on the position of the hyoid bone have been performed in the areas of dysphagia or malocclusion, and there have been few studies related to musculoskeletal disorders. In addition, the focus of these studies was mainly on the height and the anteroposterior position of the hyoid bone, while lateral deviation was not studied. In addition, there was no clinical measurement.

Therefore, this study presented a clinical method to measure the lateral deviation of the hyoid bone and analyzed its reliability. If clinical measurement methods such as the center point test and lateral motion test are used to measure lateral deviation of the hyoid bone, rather than radiation or 3D computer imaging, time and cost will be saved. The center poi nt and lateral motion tests are easy to use and safe for h uman body. These benefits will increase the use of interventions involving the hyoid bone, and the application of these interventions will create synergies in the treatment of the head, neck and scapula.

The limitation of this study was that it was difficult to generalize the results of the study; the number of the subjects was not high enough. In addition, the influence of head and neck posture change on measurement were controlled as much as possible, but minute changes in posture could not be controlled. Furthermore, the effect of tongue movement was not considered. The criteria validity was low in previous studies evaluating lateral deviation by center point or lateral motion measurements. Therefore, the validity of the clinical measurement method and the normal range of lateral deviation of the hyoid bone should be studied for further research. Also, since the position of the head and the neck are different depending on the posture, it is necessary to compare the results according to standing, sitting, and supine position in future studies. Since the hyoid bone is an important structure to be considered in the treatment of the head, neck, and scapula, various approaches related to the clinical measurement and intervention of the hyoid bone should be performed.

Conclusion

The purpose of this study was to measure the lateral deviation of the hyoid using the center point test and lateral motion test and to analyze their reliability. As a result of the study, the center point test showed good intra-rater reliability and moderate inter-rater reliability. The lateral motion test showed substantial reliability both in intra- and inter-rater reliability. Although the clinical measurement methods used in this study showed high reliability, it is necessary to verify the reliability and validity through the scientific research methods in order to generalize because the number of subjects is small.

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This article was received June 21, 2019, was reviewed June 21, 2019, and was accepted July 22, 2019.