Ultrasound guided joint space distance changes during manual traction of acromioclavicular joint in young and healthy adults

Ultrasonograficzne obrazowanie zmian przestrzeni stawowej podczas manualnej trakcji stawu barkowo-obojęzycznego u młodych i zdrowych dorosłych

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Abstract

Introduction: Manual traction is a commonly used technique in manual therapy. However, depicting changes in joint space distance via real time imaging during traction is seldomly applied. The aims of the study were to identify ACJ joint space distance changes during manual traction and creation of a classification of the techniques upon the largest change in the resultant parameter (l) representing joint space distance.

Material and methods: Thirteen healthy volunteers were examined unilaterally. Acromioclavicular joint space distance changes were measured with dynamic ultrasound imaging during following manual traction techniques: International Academy of Orthopedic Medicine technique (IAOM AC), Karel Lewit's Prague School of Manual Medicine & Rehabilitation technique (LAC) and author's own proposition (B AC). The differences in joint space distance between resting position (RP) and the traction technique position, created three parameters of displacement – horizontal (x), vertical (y) and (l) - the resultant component.

Results: Parameters were not coherent with normal distribution. Statistical differences showed significance in the (x) parameter for IAOM AC compared with L AC ($p < 0,0183$) and B AC ($p < 0,02$). All techniques presented a significant increase of the resultant distance (l), compared with RP as the reference value - IAOM AC $p < 0,0036$, L AC and B AC $p < 0,0000$. In few cases L AC decreased the distance in the (x) parameter, but not significantly.

Conclusions:

1. Significant changes of (x) parameter did not correspond with the significance of the resultant parameter (l), which prevented authors from creating a classification of the techniques.
2. All traction techniques used in the study increased the joint space distance compared to RP, which confirms traction's theoretical assumptions.
3. For clinical purpose the change of (x) parameter may prove crucial for therapy's effectiveness, despite lack of change in the joint space distance in the resultant parameter (l) by itself.

Key words: acromioclavicular joint (ACJ), ultrasound, deep joint space, manual therapy traction

Streszczenie

Wstęp: Trakcja jest szeroko stosowaną techniką w terapii manualnej. Jednakże obrazowanie zmian przestrzeni stawowej w czasie rzeczywistym podczas trakcji jest rzadko wykorzystywane. Celem badań był pomiar zmian przestrzeni stawowej podczas trakcji oraz stworzenie klasyfikacji technik na podstawie największej zmiany parametru wypadkowego (l) reprezentującego wymiar przestrzeni stawowej.

Materiał i metody: W badaniach wzięło udział trzynaścioro ochotników. Zmiany przestrzeni stawowej stawu barkowo-obończykowego obrazowano przy pomocy dynamicznego badania ultrasonografem podczas wykonywania trzech technik trakcyjnych terapii manualnej. Techniki zaczerpnięto z dwóch koncepcji Terapii Manualnej: International Academy of Orthopedic Medicine – Międzynarodowej Akademii Medycyny Ortopedycznej (IAOM AC), Praskiej Szkoły Medycyny Manualnej i Rehabilitacji Karela Lewita (L AC) oraz wprowadzono autorską technikę (B AC). Pomiary wykonano jednostronnie w pozycji spoczynkowej stawu (RP), dla uzyskania wartości referencyjnej oraz podczas wprowadzenia siły trakcyjnej w poszczególnych technikach. Obliczenia pozwoliły wyznaczyć trzy parametry przesunięcia – poziomego (x), pionowego (y) oraz wypadkowego (l).

Wyniki: Wybrane parametry nie wykazały rozkładu normalnego. Istotność statystyczną dla parametru (x) wykazała zmiana w technice IAOM AC w porównaniu do L AC ($p < 0,0183$) oraz B AC ($p < 0,02$). Wszystkie techniki wykazały istotne zmiany wypadkowego parametru (l) w porównaniu do wartości referencyjnej – IAOM AC $p < 0,0036$, L AC and B AC $p < 0,0000$. W niewielkich przypadkach przestrzeń stawowa (parametr x) w technice L AC zmniejszyła się, jednak zmiany nie wykazały istotności statystycznej.

Wnioski:

1. Stworzenie klasyfikacji technik czy ich klinicznych rekomendacji okazało się niemożliwe ze względu na brak zbieżności pomiędzy istotnością zmian parametrów: poziomego (x) z wypadkowym (l).
2. Wszystkie techniki trakcyjne spowodowały zwiększenie przestrzeni stawowej, co jest zgodne z ich założeniami teoretycznymi.
3. Dla celów klinicznych zmiana parametru składowego (x) może mieć znaczący wpływ na efektywność terapii, pomimo braku zmian przestrzeni stawowej na poziomie wektora wypadkowego (l).

Słowa kluczowe:

staw barkowo-obończykowy (ACJ), ultrasonografia, głęboka przestrzeń stawowa, terapia manualna, trakcja

Introduction

Acromioclavicular joint (ACJ) has been well described anatomically [1-8].

The joint surface on the acromion is concave, this determines the treatment plane of the joint for all manual therapy (MT) techniques [5,6,9]. It acts like a ball and socket joint [1,5,6]. It allows the anteroposterior gliding and rotation of the acromion on the clavicle. Together with the sternoclavicular joint (SCJ) they contribute to the mobility of the whole shoulder girdle [4].

In MT, traction is defined as a non-physiological movement of the joint surfaces performed perpendicularly to the concave joint partner. It is used for pain relief, pre-mobilization warm-up (prior to other specific mobilization techniques), or mobilization technique itself on the condition that a real separation between joint surfaces is possible to reach [9]. ACJ is one of them, where glenohumeral is not [10,11].

According to 2006th National Health Interview Survey, 30% of adults reported experiencing some type of joint pain during the preceding 30 days which is a serious social issue [12]. One of possible treatment options could be traction, which provide pain relief, regain of ROM by eliminating the mechanical restraint in the joint [13]. All this factors have a positive influence on activities of daily living, which is the main goal of every therapy.

Authors consider mobilization as a stretching technique of the capsule, with aim to increase the joint's ROM. Some MT concepts distinguish grades of traction mobilization in respect of applied force [14]. Others don't, explaining that by the lack of objectivity.

Ultrasonography (US) is widely recognized, non-invasive, no radiation hazard, low cost, real-time dynamic examination for both active and passive motion [3,15,17]. The limiting factor of US is wave depth penetration [18]. Nevertheless, considering all the advantages

of US it seems to be the perfect tool for measuring the ACJ as many authors proved in their researches [19,20].

The best parameter for biometric characteristic of the joint is the deep joint space measured from superior perspective.

Based on the aforementioned premises, the study setup had two goals. The cognitive goal was to identify ACJ joint space changes during the application of the traction visualized by US. The practical goal was to create a classification and clinical recommendations for particular traction techniques, where resultant parameter (I) values would be the determinant of the traction.

Material and methods

Thirteen healthy volunteers participated in the study (age $25,4 \pm 3,5$ years, weight $74,5 \pm 14,3$ kg, height $177,7 \pm 8,3$ cm). All participants were familiarized with the purpose and the course of the examination and agreed to join the experiment by an oral consent. Exclusion criteria consisted of presence of any ACJ symptoms during the history and/or functional examination which eliminated the subject from the following steps of the procedure.

IAOM examination protocol was used for both subjective and objective parts [21].

The subjective part consisted in the history of shoulder girdle trauma, past or present pain occurrence (Numeric Pain Rating Scale) or any other non-traumatic occurrences of symptoms.

The objective part consisted in ROM examination both for shoulder girdle (elevation through abduction, scaption and flexion) and the glenohumeral joint itself (flexion, extension, abduction, adduction, scaption, external and internal rotation). Subsequently, ACJ provocative tests were performed (Paxinos, O'Brien, Resisted Horizontal Abduction, Bad Cop) followed by ACJ palpation to confirm pain provocation.

Ultrasound device (MyLab™25 Gold Esaote, Genova, Italy; frequency 12Hz) with a flat transducer was used. Images were taken from a superior projection of ACJ.

Traction techniques were derived from two MT Concepts: IAOM and Karel Lewit Concept [22]. Additionally, one other technique was proposed by the authors. The choice upon using this technique was based on the therapist's clinical experience, where the technique provided a lot of pain-relief effect while working with symptomatic patients. The main goal of including it into the protocol was a desire to find out if it would create a comparable increase in the joint space like the official MT techniques. A therapist with a ten year clinical experience in physical as well as manual therapy performed the procedure with every participant in the study. Due to this fact, the consistency of the grip, the application of force and hands alignment for each technique was maintained. The therapist was not blinded for the purpose of the study, as he was one of the originators and authors of this paper.

US operator who was performing the measurements has over 15 years of experience in imaging musculoskeletal system in particular.

International Academy of Orthopedic Medicine (IAOM AC)

Fig. 1. IAOM AC. Preparation with putting a roll between the medial edge of the scapula and thoracic spine, to free the scapula to move. Application of the traction force through the coracoid process (arrow). Therapist's forearm is in line with the clavicle [21].

Karel Lewit Concept (L AC)

Figure 2. L AC. Application of the traction force through the humerus (arrow) with a grip on the epicondyles. Trunk stabilization through the scapula and the rib cage (solid line) [22].

Author's technique (B AC)

Fig. 3. B AC. Traction force application through the patient's arm and forearm by a leverage grip on the elbow (arrow).

Joint space was defined as the distance between two bony edges of the clavicle and acromion which were most standing out according to the US examiner – as suggested elsewhere. The procedure included four measurements – reference distance in the RP of ACJ and the three other ones during consecutive traction techniques. The measurements were presented in millimeters [mm]. The transducer was taken off the skin every time between the tries to enable the therapist putting the patient's arm in the proper position for

$$|\Delta x| = \sqrt{[RP(x_2 - x_1) - IAOM(x_2 - x_1)]^2}$$

$$|\Delta y| = \sqrt{[RP(y_2 - y_1) - IAOM(y_2 - y_1)]^2}$$

$$|\Delta l| = \sqrt{[RP(l) - IAOM(l)]^2}$$

performance.

The subsequent analysis included entering the collected data into a frame of reference to designate the coordinates (figure 4). Coordinates (x; y) were used for calculations with the following equations:

Fig. 4. US image with joint space distance (D1) marked (solid line) and designation of the (x1,2, y1,2) coordinates for measuring the displacement between techniques.

Three parameters were determined: $|\Delta x|$, $|\Delta y|$ and $|\Delta l|$, where (x) applies to horizontal dimension, (y) to vertical dimension, whereas (l) applies to the resultant of the two aforementioned variables, and represents the joint space distance. The parameters were statistically analyzed using Shapiro-Wilk's test and Kruskal-Wallis's test. The significance level was set at $p < 0,05$.

Results

None of the analyzed parameters - $|\Delta x|$, $|\Delta y|$ and $|\Delta l|$ - were coherent with normal distribution, $p < 0,3545$, $p < 0,0111$ and $p < 0,0111$ respectively. Therefore, analysis of statistical differences between particular techniques was used. Additionally a box plot tool was used.

Parameter $|\Delta x|$

Box plot shows median values as middle values of every set and also the distribution of parameter (x) values in particular quartiles for each traction technique (fig.5).

Fig. 5. A box plot chart presenting median values and quartiles distribution for $|\Delta x|$ for traction techniques. Kruskal-Wallis's test.

L AC showed outliers both in positive and negative direction. The latter shows that the joint space decreased in horizontal dimension in some of the patients. This behavior stands opposite to the theoretical guidelines of

traction which aims at increasing the resultant vector (I) and the horizontal dimension (x). IAOM AC presents the biggest range of values among particular quartiles (fig.5).

Tab.1. Analysis of statistical differences for $|\Delta x|$ between traction techniques. Significance marked as (*).

Dependent: $ \Delta x $	Kruskal-Wallis's Test: H(3, N=52) = 13,43021 p=,0038			
	RP R: 31,538	IAOM AC R: 36,462	L AC R: 18,846	B AC R: 19,154
RP		1,0000	0,1964	0,2232
IAOM AC	1,0000		*0,0182	*0,0215
L AC	0,1964	*0,0182		1,0000
B AC	0,2232	*0,0215	1,0000	

H (3, N=52), where H stands for a critical value (degrees of freedom, N - general number of cases considered combined with the degrees of freedom).

IAOM AC underwent a statistically significant change regarding (x) parameter using the analysis of statistical differences. IAOM AC in relation to L AC $p < 0,0183$ and B AC $p < 0,02$.

Parameter $|\Delta y|$

Considering the (y) parameter, no abnormalities were observed. As mentioned previously, IAOM AC presented the biggest range of values among particular quartiles.

None of the techniques showed significant changes regarding horizontal dimension ($p < 0,1103$).

Parameter $|\Delta l|$

As a reminder, the measurement of the joint space in RP technique was used as a reference value for measurements of other techniques. Therefore, the RP result stands as zero in figure 6.

Fig. 6. A box plot chart presenting median values and quartiles distribution for $|\Delta l|$ for traction techniques. Kruskal-Wallis's test.

L AC again showed a different behavior, apart from outliers, faroutliers appeared - both of them in positive direction.

Tab. 2. Analysis of statistical differences for $|\Delta l|$ between traction techniques. Significance marked as (*).

Dependent: $ \Delta l $	Kruskal-Wallis's Test: H(3, N=52) = 31,89409 p=,0000			
	RP R: 7,0000	IAOM AC R: 27,835	L AC R: 35,654	B AC R: 35,962
RP		*0,0036	*0,0000	*0,0000
IAOM AC	*0,0036		0,9851	0,8943
L AC	*0,0000	0,9851		1,0000
B AC	*0,0000	0,8943	1,0000	

H (3, N=52), where H stands for a critical value (degrees of freedom, N - general number of cases considered combined with the degrees of freedom).

Analyses of statistical differences show that all of the traction techniques increased the resultant dimension of the joint space in relation to the reference measurement (RP).

No significant changes were observed between techniques, which makes it impossible to create a classification based on the criteria of the increase in the joint space dimension.

The most interesting phenomenon was observed when two parameters (x) and (l) were compared with each other. The outcome revealed that significant changes of (x) parameter in IAOM AC did not correlate with significant changes in the resultant (l) parameter. Thus, it seems very important to analyze every parameter separately (x), (y), (l), so that the significance of the components is not missed.

Discussion

The results regarding the joint space distance showed average and mean values of $5,7 \pm 2,0$ mm, which despite position of the patient (minor methodological difference) is consistent with values proposed by others [16,23,24]. Disadvantage of this kind of research is lack of standard US examination protocol for scientific researches.

The first parameter describing the ACJ is the joint space. The literature differentiates two possible measurements of the joint space – deep and superficial. The deep one was defined as the distance between the two deep articular bone rims seen by US [2]. Poncelet et al. who conducted one of the first attempts to unify the examination procedure aimed to describe anatomically and biometrically a normal ACJ. From all the factors presented, only the deep joint space had significant changes. That was the main reason why the authors recommended this factor, as the best characteristic.

The second disputed issue is the choice of proper projection to image the joint. Publications present two possibilities – superior or anterior-superior. Authors explicitly recommend superior projection, because it visualized up to 70% of all the joint structures and parameters chosen

for their paper. Based on the experience and conclusions described by others, it was chosen to use deep joint space parameter and the superior projection to visualize the joint.

Although many undisputed advantages of US, several authors pointed out some limiting factors. First and foremost the learning curve is long [3]. The same concerns the inter-researcher consistency. The second flaw is high subjectivity of reading and interpreting the images [20]. In contradiction to this premise Schmidt et al. stated that they reached the rate of agreement (objectivity) between two investigators at the level of 0,96 (0,78-0,99) [23]. In this paper disadvantages were minimized by presence of an operator with over 15 years of experience in US imaging.

Due to a small number of papers describing changes of joint space distance, there is a lack of examination and data analysis protocol. There is a tendency to use the resultant distance after examiner's mark on the screen. The main limitation of this behavior is omitting the two components which reduce the analysis.

Taking those drawbacks into consideration, the authors extended the data collection and analysis by introducing a new algorithm. It contains entering data into the frame of reference with the aim to designate their (x, y) coordinates, to provide more accurate interpretation. The results showed significance for both parameters: resultant (l) and (x) as its component, even though changes of the (x) parameter did not influence the (l) parameter directly.

All of the techniques increased the resultant parameter (l) confirming their influence on joint space dimension, according to their respective purposes. This phenomenon appeared despite the fact, that the results of some subjects – (x) parameter in L AC – actually showed lesser values than the mean for respective measurements. Nevertheless this opposite behavior was not significant, so that it could not change the overall results.

Other researchers did not mention anything about traction techniques narrowing the joint space, hence it is quite difficult to refer to other papers.

Nowadays, there are several coexisting MT concepts which have the same definition of traction. The selection of techniques was based on their popularity and clinical treatment observations.

The main difference between traction techniques concerned is the starting position which designated various arrangements in relation to gravity. The next differentiating factor concerning the amount of force was the direction of force application. This feature subdivides the techniques into two groups of techniques: direct, where the therapist grips one of the bones that build the joint (IAOM AC) and indirect, where the therapist applies the force through other joints (L AC, B AC).

Lack of standardization in force application is often the main objection of researchers [14,25]. It is difficult and actually not necessary to assess the amount of force

applied, because clinically the therapist is adjusting the amount of force applied according to the patient's feedback. In an asymptomatic group the measurement of the distance is the only indicator of traction, whereas in symptomatic individuals perception of pain decrease would be the second indicator for technique's effectiveness.

Performance of the same study protocol on a symptomatic group could be a subject for future investigation.

Conclusions

1. Significant changes of (x) parameter did not correspond with the significance of the resultant parameter (l), which prevented authors from creating a classification of the techniques.
2. All traction techniques used in the study increased the joint space distance compared to RP, which confirms traction's theoretical assumptions.
3. For clinical purpose the change of (x) parameter may prove crucial for therapy's effectiveness, despite lack of change in the joint space distance in the resultant parameter (l) by itself.

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