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Intra-articular volume assessment in glenohumeral instability

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Abstract It is commonly claimed that instability of the shoulder is associated with an enlarged joint volume. The purpose of our study was to assess the intra-articular volume in acute and chronic glenohumeral dislocation. Sixty-seven patients were examined by intra-articular infusion of saline solution. Three groups could be formed. Group 1 ($n = 51$) consisted of patients with first time traumatic dislocation, group 2 ($n = 8$) of cases with recurrent post-traumatic dislocation. The patients of group 3 ($n = 8$) suffered from impingement syndrome and served as the control group. The joint volume was correlated to the body surface area (BSA). We found a strong correlation between height, sex and intra-articular joint volume. There was no statistically significant difference in joint volume correlated to BSA between the three groups. There is no statistically significant difference in joint volume correlated to BSA in patients with traumatic anterior instability, chronic instability and individuals without glenohumeral instability.

Keywords Joint-volume · Shoulder instability · Pathophysiology of shoulder dislocation

Introduction

The pathophysiology of shoulder instability is commonly claimed to be associated with an enlarged intra-articular glenohumeral joint volume [2–6]. Even though only few authors could prove a significantly altered volume in shoulder instability, the surgical success of capsular shift in anterior–inferior instability supports this thesis [6]. To our knowledge no investigation has been performed to examine if there are differences in joint volume between acute and chronic instability of the glenohumeral joint. The aim of our study was to assess the intra-articular volume in acute and chronic glenohumeral instability.

Patients and methods

Sixty-seven patients (54 males, 13 females; mean age 29.8 years; range 18–52 years) were examined. Diagnosis and grouping were made by clinical evaluation, radiodiagnostics and mri-arthrography. The height and weight of all patients was measured the day before surgery.

Group 1 consists of 51 patients with the first event of anterior traumatic dislocation of the shoulder (mean age 28.14 years; range 18–51 years). Only patients with a Bankart lesion and missing effluvium in the mri-arthrography were included. Fourty-five individuals were males (mean age 27.4 years; range 18–50 years) and six females (mean age 27.4 years; range 24–51 years).

Group 2 includes eight patients (mean age 29.7 years; range 21–37 years) with recurrent post-traumatic dislocation of the shoulder (four males: mean age 29 years; range 24–31 years; four females: mean age 29.6 years; range 21–37 years).

Group 3 is the control collective. It involves eight patients (mean age 52.9 years; range 42–98 years): [six males (mean age 55.8 years; range 42–98 years], two females (mean age 44 years; 43 and 45 years) with the diagnosis of impingement syndrome.

The mean height among all patients was 177.2 cm (range 158–200 cm; male: 179.5 cm; range 164–200 cm; female: 168.2 cm; range 158–180 cm), the average weight was 73.85 kg (range 47–95 kg; male: 76.8 kg; range 60–95 kg; female: 62.1 kg; range 47–82 kg).

All patients were in lateral decubitus position with double arm traction (5 kg horizontally, 3.5 kg vertically). Arm abduction angle was measured as 30° with 0° rotation in the plane of the scapula, in order not to place asymmetric tension on the anterior and posterior capsules. To avoid alteration of the capsule volume no examination was performed under anesthesia. Arthroscopy was performed in standard technique. After venting of the shoulder the 4 mm standard arthroscope was inserted via the posterior portal. Physiological saline solution was infused into the joint with a hydrostatic inflow pressure of 100 cm. After equilibrium was achieved and did not alter for 30 s the infusion was stopped. The joint volume was ascertained by weighing the residue of the saline solution. The readings were correlated to body surface area (BSA) to determine body size in relation to joint volume.

$$\mathrm{BSA} = \frac{[\text{height (cm)} + \text{weight (kg)}] - 60}{100} = \mathrm{m}^2.$$

Statistical significance in correlation to joint volume/BSA and diagnosis was assessed with the general linear model in a univariant analysis of variance, the student's *t*-test and the Bonferroni test. As a significant difference α was set as $p = 0.05$.

Results

The joint volume was assessed in each patient. Among the 60 male patients the mean joint volume was 43 ml (range 18–121 ml). The largest average volume was measured in the six patients with subluxation (50.7 ml; range 35–78 ml), the smallest in the six patients with impingement syndrome (38.3 ml; range 18–42 ml). In the 15 female patients we found a mean joint volume of 33.3 ml (range 15.5–60 ml) with the largest volume in group 1 (mean 35.4 ml; range 15–60 ml), the smallest in impingement syndrome (mean 27 ml; range 26–28 ml). There was a strong correlation between sex and joint volume ($p = 0.0001$). Furthermore we found a significant correlation between height ($p = 0.006$), weight ($p = 0.01$) and joint volume (Figs. 1, 2). Additionally we noticed that significantly more men than women had a traumatic dislocation of the shoulder ($p = 0.0001$). To avoid a systematic statistical error we applied the glenohumeral joint volume to the BSA [vol. (ml)/m^2 BSA—index].

Mean BSA was 1.902 m^2 (range 1.45–2.14 m^2; male 1.96 m^2; range 1.61–2.14 m^2; female 1.65 m^2; range 1.45–1.85 m^2). There was no statistically significant difference in BSA between the four groups. We found a mean vol. (ml)/m^2 BSA – index of 21.8 (6.37–59.02) ml/m^2 (Fig. 3). In male patients we assessed a mean index of 21.82 ml/m^2 BSA (range 6.37–59.02) in female patients a mean index of 21.67 ml/m^2 BSA (range 11.73–44.14) (Fig. 4).

The joint volume (ml)/BSA (m^2) – index showed no statistical difference between patients with first time traumatic dislocations (22.57 ml/m^2; 9.06–59.02), subluxations (17.92 ml/m^2; 6.37–24.74), recurrent post-traumatic dislocations (24.75 ml/m^2; 11.37–37.14) and impingement syndrome (17.79 ml/m^2; 9.42–42.99) (Fig. 5).

Discussion

Joint volume is considered to be enlarged in shoulder instability [2–6]. Other authors found that glenohumeral volume is not significantly altered in both shoulders in individuals with unilateral instability of the shoulder [7]). In this study a pressure/volume curve was recorded during continuous saline infusion in 20 patients. Joint volume was correlated to body surface area. In agreement with this article we did not find significant differences in joint volume in individuals with shoulder instability and healthy patients. In contrast to our setup Sperber and Wredmark [7] performed saline infusion upto 180 mmHg. Despite this difference the findings

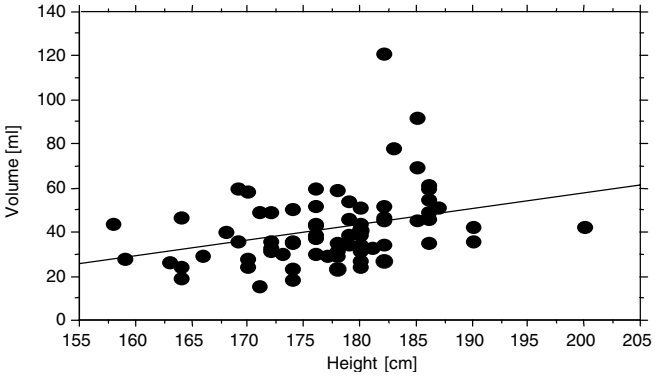

Fig. 1 The influence of body size on glenohumeral volume. The bigger the individual the larger the joint volume

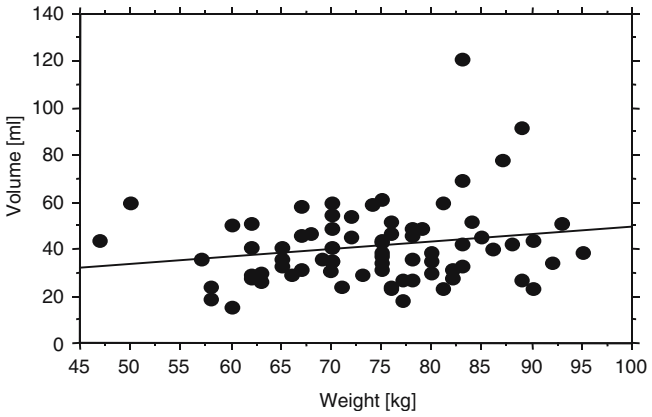

Fig. 2 The influence of weight on intra-articular glenohumeral joint volume. Even though the joint volume depends on the weight, the influence is less than that of height

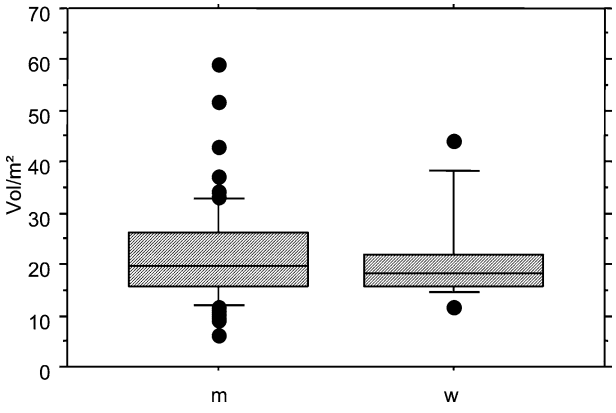

Fig. 4 Intra-articular glenohumeral joint volume correlated to BSA and sex. There is no significant difference between sexes

comply with ours. To our mind the way of achieving equilibrium is insignificant. Due to the elasticity of the capsular, the absolute amount of saline solution is more in infusion with higher pressure. Since Sperber and Wredmark [7] and we correlated the amount of saline solution to BSA the absolute amount is of no interest in recording joint volume. Pressure-controlled infusion is of use in assessing capsular elasticity. For ascertaining joint volume a simple setup like ours is suitable and due to its simplicity less susceptible to confounders.

Hashimoto et al. [1] evaluated the intra-articular pressure in shoulders with contractures, shoulders with rotator cuff tears and unstable shoulders. They found a slower pressure increase and a more limited range of pressure changes in unstable shoulders than in healthy shoulders. Although this group could not show any significant differences, it was estimated that their findings suggest relaxation of the joint capsule in shoulder instability. Our findings could neither verify nor refute if there is relaxation of the capsule. Nevertheless, a relaxation of the capsule would suggest an increased intra-articular volume. Our findings could not reveal an altered joint volume.

Lubowitz et al. [2] quantified the effect of inferior capsular shift on shoulder volume in four fresh frozen cadaveric shoulders. Three techniques were used to determine the glenohumeral joint volume before and after treatment. Joint volume was reduced in 57% on an average. It was concluded that volume is an indicator of instability and laxity. However, the number of shoulders was too small for statistical assessment. Since inferior capsular shift is a successful surgical procedure in glenohumeral instability it seems reasonable to suggest that joint volume is an important indicator in glenohumeral stability. Since we could not find any proof of altered joint volume in glenohumeral instability, the benefit of inferior capsule shift seems to be different. It could be suspected that the reflex circuit of the capsular mechanoreceptors (Pacini-bodies) is restored after capsular shifting. Further investigations should be performed.

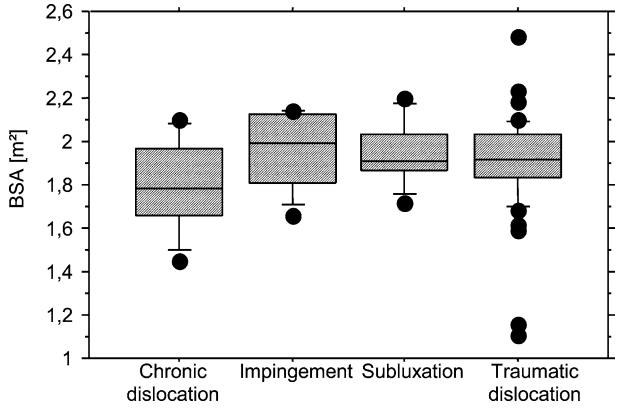

Fig. 3 The distribution of BSA in the four groups. Since there are no statistically relevant differences joint volume can be correlated to BSA

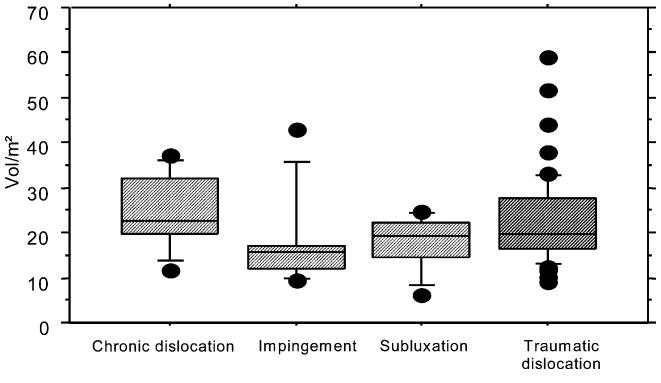

Fig. 5 Intra-articular glenohumeral joint volume and diagnosis. There are merely differences in emphasis. No significant difference could be found

Conclusion

There is no statistically significant difference in joint volume correlated to BSA in patients with traumatic anterior instability, chronic instability and patients with no glenohumeral instability.

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