Preliminary ultrasound evaluation of the rotator cable in asymptomatic volunteers[☆]

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KEYWORDS

High-resolution
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Shoulder;
Rotator cuff cable.

Abstract *Purpose:* To characterize the rotator cable high-resolution ultrasound appearance in asymptomatic shoulders of volunteers of different age.

Materials and methods: IRB approval and volunteers' written consent was obtained. Excluding subjects with known shoulder affections, we screened 24 asymptomatic volunteers. Supraspinatus and infraspinatus tendons high-resolution ultrasound evaluation was performed according to standard scan protocols, further excluding shoulders with partial/full-thickness cuff tears. Thus, we studied 24 shoulders in 12 young volunteers (age range 21–39 years, mean age 33 ± 8 years) and 21 shoulders in 11 elderly volunteers (age range 62–83 years, mean age 75 ± 45 years). For each shoulder, we noted rotator cable visibility and its thickness and width. Fisher's and *U* Mann–Whitney statistics were used.

Results: Rotator cable was less frequently detected in young than in elderly volunteers (5/24 vs. 11/21 shoulders; $P = 0.034$). When detected, rotator cable was significantly thicker in young (range 1.2–1.5 mm, mean thickness 1.3 ± 0.1 mm) than in elderly (range 0.9–1.4 mm, mean thickness 1.2 ± 0.1 mm) volunteers ($P = 0.025$), while its width was not significantly different in young (range 4.5–7.1 mm, mean 5.6 ± 1.1 mm) compared to elderly (range 2.5–7.1 mm, mean 4.2 ± 1.4 mm) volunteers ($P = 0.074$) although a tendency can be highlighted.

Conclusions: Ultrasound demonstrated the different consistency of rotator cable in young and elderly asymptomatic patients, with high interobserver reproducibility.

Sommario *Obiettivo:* Caratterizzare l'aspetto ecografico del rotator cable mediante ecografia ad alta risoluzione in spalle asintomatiche di volontari di età differente.

Materiali e metodi: È stata ottenuta l'approvazione del Comitato Etico e il consenso informato dei volontari. Escludendo i soggetti con patologia nota di spalla, abbiamo studiato 24 volontari asintomatici. È stato eseguito un esame ecografico ad alta risoluzione secondo le linee guida, escludendo ulteriormente le spalle con lesioni parziali o complete di cuffia. Pertanto, abbiamo

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studiato 24 spalle in 12 volontari giovani (range 21–39 anni, età media 33 ± 8 anni) e 21 spalle in 11 volontari anziani (range 62–83 anni, età media 75 ± 5 anni). Per ogni spalla, abbiamo registrato la visibilità del rotator cable e il suo spessore e larghezza. Sono stati usati i test *U* Mann–Whitney e Fisher.

Risultati: Il rotator cable è stato riconosciuto meno di frequente nei volontari giovani rispetto agli anziani (5/24 contro 11/21 spalle; $P = 0.034$). Quando visibile, il rotator cable era significativamente più spesso nei volontari giovani (range 1.2–1.5 mm, media 1.3 ± 0.1 mm) rispetto agli anziani (range 0.9–1.4 mm, media 1.2 ± 0.1 mm; $P = 0.025$), mentre la sua larghezza non era significativamente differente tra volontari giovani (range 4.5–7.1 mm, media 5.6 ± 1.1 mm) e anziani (range 2.5–7.1 mm, media 4.2 ± 1.4 mm; $P = 0.074$), per quanto possa delinearsi una tendenza.

Conclusioni: L'esame ecografico ha dimostrato la diversa consistenza del rotator cable in volontari asintomatici di età differente.

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Introduction

The rotator cable is a thick deep bundle of fibers perpendicular to the supraspinatus tendon that has been described for the first time by Clark et al. in 1990 [1] and called "rotator cable" by Burkhart et al. in 1993 [2]. This structure surrounds a hypovascular crescentic area of the rotator cuff named as "rotator crescent" that is more prone to tears compared to the rest of the cuff [1,2].

Burkhart et al. [2] compared the cable–crescent complex to a suspension bridge in which the rotator cable plays as a "stress-transfer" in shoulder biomechanics, suggesting also there may be two different functional classes of rotator cuff based on the behavior of the cable–crescent complex under load: *cable dominant* (in which the crescent is stress-shielded by the cable) and *crescent dominant* (in which there is no stress-shielding of the crescent). Cable dominant cuffs are predominant in elderly (>60 years) shoulders in reason of the increasing reliance of the stress-shielding action that protects the relatively avascular crescent tissue from tears [2].

High-resolution ultrasound (HRUS) plays a central role in rotator cuff imaging [3,4] and it could be used to describe the shoulder action and the clinical implications of each rotator cuff structure. Being quick, non-invasive, and allowing a dynamic evaluation, HRUS is ideal to focus on a structure as implicated in the shoulder biomechanics as the rotator cable [4,5].

On HRUS scans the morphology of the rotator cable could vary from a thick cable of fibers to thin flattened fibers traversing deep to the rotator cuff (Fig. 1), as reported by Morag et al. [5]. Thus, an accurate HRUS characterization of a rotator cuff tear and its relationship to the rotator cable may be important. To our latest knowledge, no research about aging and HRUS of the rotator cable is available.

The purpose of our preliminary experience is to characterize the HRUS appearance of the rotator cable and to compare the HRUS consistency of such structure in young and elderly asymptomatic volunteers.

Material and methods

Institutional Review Board approval and volunteers informed consent was obtained.

Twelve young (6 males and 6 females with age range between 21 and 39 years, mean age 33 ± 8 years) and twelve elderly (6 males and 6 females with age range between 62 and 83 years, mean age 75 ± 5 years) asymptomatic volunteers were prospectively included in our study (24 shoulders for each group, 48 shoulders overall). Volunteers with shoulder pain, limited range of motion, or history of symptomatic shoulder or trauma were excluded from the study.

Shoulders where any partial- or full-thickness tears of supraspinatus and/or infraspinatus tendon were found were excluded from our study.

Thus, our study group was made by 24 shoulders in 12 young volunteers and 21 shoulders in 11 elderly volunteers (volunteers were excluded for the presence of partial- or full-thickness tears of supraspinatus and/or infraspinatus tendon; one elderly volunteer underwent US examination of one shoulder, ten elderly volunteers underwent US examination of both shoulders; no young volunteers were excluded from the study); 23 volunteers, 45 shoulders overall.

HRUS evaluation of supraspinatus and infraspinatus tendons was performed both on long and short axis with an ultrasound equipment (Esaote MyLab 70 XVG; Esaote Biomedica SPA, Italia) provided with a high-resolution 12–5 MHz transducer, according to the guidelines issued by the

Figure 1 High-resolution ultrasound long-axis view of the supraspinatus tendon (SSP). Yellow area highlights the crescent zone, while blue circle indicates the rotator cable. H = humerus; D = deltoid.

European Society of Musculoskeletal Radiology [6]. Images were reviewed for the presence of a hyperechoic bundle of fibers running deeply perpendicular to the supraspinatus or infraspinatus tendons in the expected location of the rotator cable. Identification of the rotator cable was based on demonstration of cable fibers deep to the cuff in both transverse and longitudinal scans. For each shoulder, we noted whether the rotator cable was detectable or not, and – if yes – its thickness (cranial-caudal dimensions) and width (medial-lateral dimensions).

Statistical analysis

We compared the number of shoulders included in the group of young volunteers in which the rotator cable was detected to that of the group of elderly volunteers using the Fisher's exact test square test. In subjects where the rotator cable was detected, we compared the thickness of the cable of young volunteers to that of elderly volunteers using the *U* Mann–Whitney test. The SPSS software (SPSS Inc, Milwaukee, IL, USA) was used. A *P*-value lesser than 0.05 was considered as significant.

Results

The rotator cable was depicted by HRUS as a hyperechoic fibrillar structure deep to the supraspinatus and infraspinatus tendons tracking in a perpendicular fashion relative to the rotator cuff fibers. This hyperechoic and fibrillar structure presented with anisotropy, appearing artifactually hypoechoic when not imaged perpendicular to the ultrasound beam.

Rotator cable was less frequently detected in young than in elderly volunteers (5/24 vs. 11/21 shoulders; *P* = 0.034). In subjects where rotator cable was detected, it was significantly thicker in young (range 1.2–1.5 mm, mean $\pm$ standard deviation 1.3 ± 0.1 mm, median 1.3 mm) than in elderly (range 0.9–1.4 mm, mean 1.2 ± 0.1 mm, median 1.2 mm) volunteers (*P* = 0.025). Rotator cable width was not significantly different in young (range 4.5–7.1 mm, mean 5.6 ± 1.1 mm, median 5 mm) compared to elderly (range 2.5–7.1 mm, mean 4.2 ± 1.4 mm, median 4.0 mm) volunteers (*P* = 0.074) although a tendency can be highlighted. HRUS images of the rotator cable are shown in Figs. 2 and 3.

Discussion

Orientation and appearance of the cable fibers differ from those of the rotator cuff tendon fibers [1,3]. Samples from the rotator cuff midline demonstrated a cable-like structure situated on the articular surface of the cuff tendons. This fibrillar structure could be identified as oriented perpendicular to the orientation of the rotator cuff tendon fibers [2,3,7].

We can explain the difference of cable appearance between young and healthy volunteers with an increased hypoechogenicity of the surrounding tendon matrix and, according to Burkhart et al. [2], for the adaptive changes

Figure 2 High-resolution ultrasound scans along the long (a) and short (b) axis of the supraspinatus tendon (SSP). Rotator cable can be clearly seen (arrows). H = humerus.

that lead the crescent to progressive thinning with advancing age.

The appearance of the rotator cable in our series is consistent with what reported by Morag et al. [5]. When detected, rotator cable was significantly thicker in young volunteers. This can partially be explained due to an increased trophism of youth volunteers tendons. The prevalence of cable dominant shoulders in elderly volunteers could be explained by the intrinsic biomechanic characteristics of that lead the rotator cable to be the last structure involved by degenerative thinning processes. Compared to what reported by Morag et al. [7], who detected the presence of the rotator cable in 3/27 asymptomatic shoulders (11%), we demonstrated an increased capability of US in depicting such structure (16/24, 66%).

Compared to previous papers that used magnetic resonance arthrography to evaluate rotator cable consistency [8–10], US demonstrated an increased capability of demonstrating rotator cable analysis in living subjects [9]. Conversely, Kask et al. [10] successfully detected rotator cable in 6/7 magnetic arthrographies (85.7%) performed on cadaveric shoulders.

The anatomy of the cable–crescent complex and the model of the load-bearing suspension bridge suggests that the location of a rotator cuff tear is much more important than its size in terms of effect on shoulder functionality [2]. That is to say that a tear involving the rotator cable may be

Figure 3 High-resolution ultrasound scans along the long-axis of the supraspinatus tendon (arrows) showing the two functional classes of rotator cuff: cable dominant (a) and crescent dominant (b). Rotator cable (asterisks) was found to be significantly thicker in cable dominant cuffs.

biomechanically much more significant than a tear that involves the rotator crescent only, even though smaller in dimensions.

Being shoulder arthropathy very frequent in elderly subjects, we can speculate that our results could have an important implication on the management of elderly patients with rotator cuff tears. In fact, an important topic in the biomechanics of articular-sided rotator cuff tears is they reflect damage to the superior complex rather than to the rotator cuff tendons. This damage compromises the head-depressing and centering effect normally performed by the superior complex. When the superior complex remains intact or is only partially damaged, it may limit the retraction of the torn rotator cuff tendons. This effect has already been demonstrated in the studies of Burkhart et al, who proved that the rotator cable is the pivot in maintaining normal kinetics in the presence of massive rotator cuff tears. Being able to demonstrate the integrity of rotator cable in a torn cuff could have an important role in the conservative or surgical management of elderly patients. However, no data in our series are available to support such hypothesis.

In our study, the small number of volunteers and the absence of a surgical control of our data, being our evaluation based on healthy volunteers, represent the main limitation. However, this is the only study available in literature that uses HRUS to demonstrate that cable

dominant cuffs are more frequent in elderly subjects, as stated by Burkhart.

Conclusion

HRUS is an emergent, rapid and cheap technique able to perform an accurate, non-invasive and dynamic study of the rotator cable, in both young and elderly patients. Therefore HRUS may redirect the therapeutic strategies of cuff tears: conservative treatment for cable dominant patients with central tears localized in the crescent and a good muscular trophism (non progressive lesions) or surgical treatment for crescent dominant patient and for tears in eccentric position (progressive and painful lesions). However, further studies on larger samples are needed to determine if the rotator cable can be uniformly depicted at US and to determine if this information can potentially alter treatment of rotator cuff tears.

Conflict of interests

The authors have no conflict of interest to declare.

Appendix. Supplementary data

Supplementary data related to this article can be found online at [doi:10.1016/j.jus.2012.01.003](https://doi.org/10.1016/j.jus.2012.01.003).

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