Supraspinatus tendon strain analysis by intratendinous landmarks with ultrasonography

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Introduction

Rotator cuff tear tendon is one of the most common causes of shoulder pain and disability. The pattern of tendon tear is various, including intratendinous laminated tear and partial-thickness tear. There were, however, limited reports about the mechanical factors influencing on the torn pattern of rotator cuff tendon and understanding about the strain characteristics within the tendon is very poor.

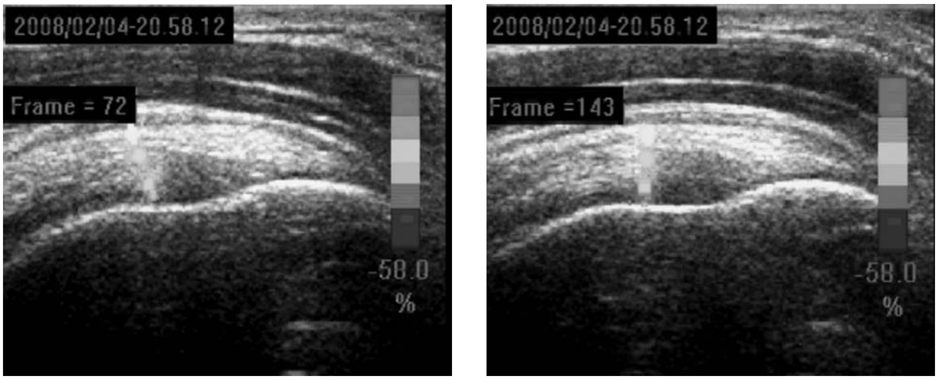
Determination of characteristics of strain within the rotator cuff tendon has relevance to understanding its biomechanical features and effect on the tear geometry. The purpose of this study was to analyze the intratendinous strain of supraspinatus tendon by landmark with high resolution ultrasound images.

Materials and Methods

Five healthy volunteer were enrolled in this study. All volunteer underwent unilateral diagnostic ultrasonography with 2D motion tracing program in long-axis direction on the supraspinatus tendon of the shoulder. The supraspinatus tendon strain was evaluated in two ways of isotonic movement and isometric movement. Each volunteer was instructed to elevate actively his arm 90° for monitoring isotonic movement and to contract shoulder muscle without movement for observing isometric maximal voluntary contraction of supraspinatus tendon.

A new 2D motion tracking program of ultrasonography was used for tracing all movement within the supraspinatus tendon. A region of interest (ROI) was placed in a vertical direction crossing the tendon at the 1cm medial from the center of tendon insertion site (Fig. 1). The ROI consisted of three kernels equally distributed from the superficial region to the deep region of supraspinatus tendon. All data of intratendinous strain and transverse displacement were obtained by calculating the movement of these three kernels.

Results



(**A**) 0° shoulder elevation. (**B**) 90° shoulder elevation.

Fig. 1. shows ROI during isotonic active movement of supraspinatus tendon depicted with 2D motion tracking program of ultrasonography. The deep part (green dot in ROI) of the tendon displace medially during arm elevation, while the superficial part (yellow dot in ROI) shows small displacement, which displacements keep linear pattern. The intratendinous strain analysis shows that there is a linear shear strain distribution among three kernels within the supraspinatus tendon.

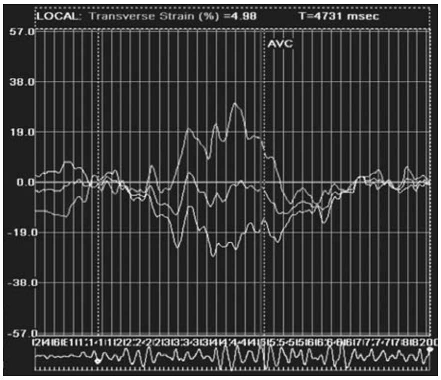


Fig. 2. shows the strain pattern of supraspinatus tendon in isotonic movement during active arm elevation. The strain of deep region (green line) is higher than that of superficial region (yellow line) of the tendon, which demonstrated the shear strain in the tendon . The strain of central region (blue line) stay in the middle range between that of superficial and deep region during arm elevation, which shows a linear strain distribution within the tendon.

Average values of strain and displacement over kernel segments in supraspinatus tendon.

	Isometric transverse displacement (mm)	Isometric transverse peak strain (%)	Isotonic transverse displacement (mm)	Isotonic transverse peak strain (%)
Superficial region	1.78	37.03	0.79	6.96
Central region	1.42	17.44	1.00	10.48
Deep region	1.05	2.48	1.25	16.75

The table shows the different motion pattern between isometric movement and isotonic movement of supraspinatus tendon. In isometric movement, the transverse displacement of superficial region (1.78 mm) is larger than that of deep region (1.05 mm) and the peak strain of superficial region (37.03 %) is also higher than that of deep region (2.48%). However, in isotonic movement, the transverse displacement of superficial region (0.79 mm) is smaller than that of deep region (1.25 mm) and the peak strain of superficial region (6.96 %) is also lower than that of deep region (16.75 %).

Discussion & Conclusion

This tendon strain analysis study demonstrates two distinct observations. First, the characteristic of strain pattern is the shear pattern between superficial and deep part within the supraspinatus tendon during both isometric and isotonic contraction. Second, the strain and displacement pattern in the supraspinatus tendon are totally different during between isometric and isotonic movement of the shoulder. We suggest a possible theory that the supraspinatus tendon has a characteristic of a shear strain during shoulder movement and the different pattern of strains between isometric and isotonic contraction alternatively aggravate the shear strain in daily activity, resulting in the laminated tear of the supraspinatus tendon. This tracking technique of high-resolution sonography seems very powerful for both quantifying and analyzing the strain in the rotator cuff tendon of the shoulder. Although further investigation regarding detailed biomechanical study is needed, we believe that these observations elucidate the strain pattern in the supraspinatus tendon, which mechanically influence on the tear pattern of rotator cuff tendon.