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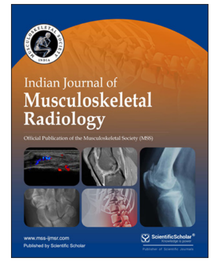

Original Article

Magnetic Resonance Imaging of Pseudo-impingement of Rotator Cuff with Strength Training

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ABSTRACT

Objective: The objective of this study was to outline a novel unique concept of secondary impingement of the muscles, myotendons, and tendons of the rotator cuff from hypertrophy as a result of strength training exercises.

Methods: In this retrospective observational study, 58 patients were referred for an magnetic resonance imaging (MRI) by the orthopedic surgeon to the radiology department over a period of 1½ years. All patients gave a history of strength training exercises and presented with clinical features of rotator cuff impingement.

Results: We identified features of hypertrophy of rotator cuff muscles, myotendons, and tendons in 12 of these 58 patients. This was the only abnormality on MRI. The hypertrophy of rotator cuff muscles and tendon bulk completely filling the subacromial space to the point of overfilling and resulting in secondary compressive features.

Conclusion: Rotator cuff impingement is a common phenomenon that can occur with various inlet and outlet pathological conditions. However, rotator cuff impingement may also result from muscle and tendon hypertrophy from strength training regimens. Hypertrophy of the rotator cuff can result in overfilling of the subacromial space, leading to secondary impingement, which we have termed as "pseudo-impingement."

Keywords: Rotator cuff impingement syndrome, Pseudo-impingement, Strength-training, Magnetic resonance imaging, Shoulder anatomy

INTRODUCTION

Rotator cuff impingement is a very common phenomenon of shoulder pain and disability of the shoulder.[1] Such a phenomenon is a multifaceted disorder, which is classified under the umbrella of rotator cuff impingement syndrome. Rotator cuff impingement syndrome can occur from various pathologies including trauma, extrinsic factors, weakness of rotator cuff muscles and tendons, abnormal motion patterns, decreased pectoral, and rotator cuff muscle flexibility.[2] Literature states that though controversial, physical therapy and athletic training might contribute toward the management of rotator cuff impingement syndrome.[2] However, our retrospective study, for the 1st time in literature, demonstrates that strength training could in itself lead to impingement pain which we have termed as "pseudo-impingement." The objective of this case series is to present uniformly occurring features of hypertrophy of the rotator cuff muscles, myotendons, and tendons in strength trainers, resulting in overfilling of the subacromial space

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with clinical features of impingement. We have termed this entity as pseudo-impingement as it results from overfilling of the subacromial space rather than from a narrowed subacromial space which is seen in traditional impingement states.

MATERIALS AND METHODS

Study design and patient selection

We performed a retrospective observational case series at our institution during a 1½ year period. The inclusion criteria included males under the age of 40 years undergoing strength training regimen, all of whom presented with clinical features of impingement. Exclusion criteria included morphological abnormality of the acromion, coracoacromial arch and acromioclavicular (AC) joint, prior shoulder injury, prior surgical history, tumor, or inadequate image quality. All patients were referred by our orthopedic surgeons.

Magnetic resonance imaging protocol

Magnetic resonance imaging (MRI) of the shoulder was performed using the standard protocol on a 1.5-T scanner using a body coil. Large field of view (36–40 cm), coronal T2 fat-saturated (TR 3200, TE 84), sagittal T2 fat-saturated (TR 3000, TE 68), coronal T1-weighted spin-echo (TR 430, TE 13), sagittal T1-weighted (TR 644, TE 13), axial T2-weighted fat-saturated (TR 2500, TE 56), and axial PD (TR 2500, TE 56) sequences were acquired. Images were obtained using a slice thickness of 3 mm.

RESULTS

Pseudo-impingement was identified on MRI in a series of 12 of 58 patients (all strength trainers) during a 1½ year period. MR consistently showed uniform hypertrophy of the rotator cuff muscles with a loss of normal intramuscular T1 fat hyperintensity, as shown in Figure 1. The supraspinatus muscle showed an excessive superior convexity in the supraspinous fossa, demonstrated by Figures 2 and 3. The myotendons and tendons of the rotator cuff were thick and demonstrated uniform dark T1 and T2 signal. This was attributed to increased tendon bulk, also from strength training. The increased tendon and myotendons bulk resulted in overfilling of the subacromial space, Figure 4. This resulted in clinical features of impingement. We have termed this novel entity as "pseudo-impingement," secondary to overfilling of a fixed bony space rather than from a narrowed subacromial space which is seen in traditional impingement. None of the patients had any abnormal features of inlet or outlet impingement, including tear or tendinosis, subacromial bursitis, reduced subacromial space, and thickened coracoacromial ligament.

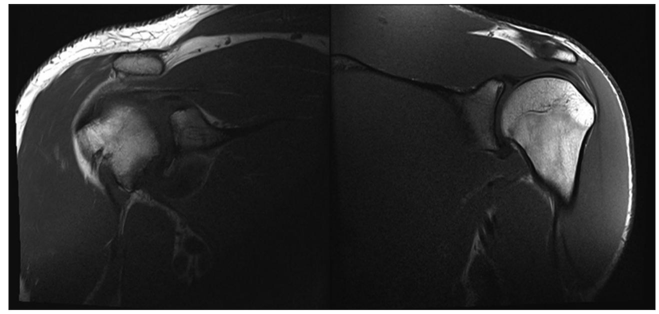

Figure 1: Coronal T1-weighted image - The rotator cuff muscles are markedly hypertrophied, bulky, with complete loss of intramuscular fat. Resultant indentation of the myotendinous junction by the acromion and effacement of the infra-acromial fat plane is seen. The overfilling of the subacromial space (more than 6mm) is termed pseudoimpingement, causing clinical impingement pain.

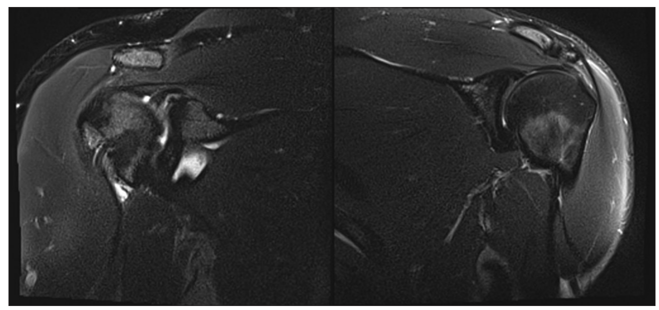

Figure 2: Coronal T2-weighted fat-suppressed image – Note the normal magnetic resonance signal appearance of the supraspinatus tendon and the lack of subacromial bursitis. The only abnormality is increased bulk of the rotator cuff muscles and myotendons from hypertrophy. Note the resultant indentation of the myotendinous junction of the supraspinatus by the acromion.

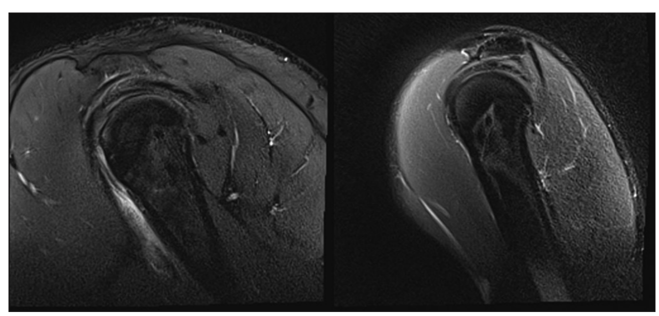

Figure 3: T2-weighted fat-suppressed image at the level of the distal insertion of the rotator cuff. Note the normal appearance of the rotator cuff at the distal most aspect of the tendons. The subacromial space is normal. There is no subacromial bursitis. No tear or tendinopathy is detected on this study.

DISCUSSION

Three main bones make up the shoulder girdle: The scapula, clavicle, and humerus. The glenohumeral (GH) joint is the most mobile of the three joints at the shoulder:

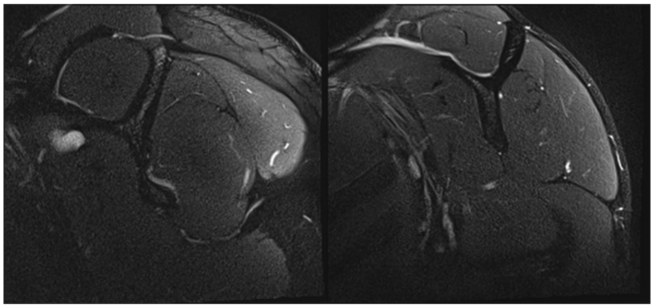

Figure 4: T2-weighted fat-suppressed image at the level of the supraspinatus fossa. Note the bulky rotator cuff muscles bellies from muscle hypertrophy. The supraspinatus muscle belly bulges beyond the confines of the supraspinous fossa.

Sternoclavicular, AC, and GH. The articulation between the humeral head and the shallow glenoid cavity is deepened by fibrocartilaginous glenoid labrum. This articulation is stabilized by the muscles and tendons of the rotator cuff that includes supraspinatus, infraspinatus, teres minor, and subscapularis.

The coracoacromial arch is formed by the acromion, coracoid process of the scapula, and the coracoacromial ligament that together roof the humeral head and the supraspinatus tendon that attaches to the greater tuberosisty. This triangular space houses the supraspinatus tendon, as it makes its way to attach to the greater tuberosity of the humerus.

The most commonly involved tendon in impingement syndrome is the supraspinatus, as it passes through the subacromial space. This can occur due to the chronic repetitive mechanical process from the conjoined tendon of the rotator cuff undergoing repetitive compression and microtrauma as confined to a limited space under the arch.[3]

The blood supply of the supraspinatus muscle is primarily derived from the anterior circumflex and suprascapular arteries. An avascular zone called the critical zone is present within the supraspinatus tendon, just proximal to its insertion into the humerus.[4] This avascular site increases with advancing age and it is at this area that impingement usually occurs, leading to chronic tendinopathy and tears.

Impingement occurs when the distance between the acromion and the humeral head defined as the subacromial space is <6 mm. Clinically, the individual indicates pain from impingement of the rotator cuff by the coracoacromial arch on elevating the arm often worse on sleeping on the affected side, called the painful arc syndrome. The symptoms can be reproduced when the arm is abducted and internally rotated, which results in the reduction of the subacromial space causing the tendon to be further compressed.[5] When the arm is abducted to 90° with 45° internal rotation, the supraspinatus tendon is in closest proximity to the anterior inferior border of the acromion.[5] Manually increasing the subacromial space by external rotation of the arm helps to relieve the symptoms.[5]

Understanding the pathological process and specific causes of impingement are enhanced with improved imaging modalities. The imaging modalities for impingement are quite diverse. X-rays are utilized, although, are usually normal in impingement syndromes.[6] At present, they are utilized to distinguish any abnormal bone that might exist, which could initially help with determining the cause of the impingement. The subacromial space, type of acromion, os acromiale, and presence of the subacromial enthesophyte are the various bony abnormalities identified on plain radiographs.

Ultrasound is the modality of choice for the evaluation of the rotator cuff related to impingement. Ultrasound helps to demonstrate rotator tendinopathy and dynamic ultrasound can further help with diagnosis of impingement by demonstrating bunching up of the supraspinatus tendon and the subacromial bursa during abduction of the arm. The patient responds with pain during the abduction.

MRI can detect tendinopathy, tendon tears, and subacromial bursitis. It also depicts the bony confines of the coracoacromial arch including the type of acromion, downsloping of the lateral end of the acromion, the subacromial space, the AC joint, and the status of the coracoacromial ligament.[7]

Patients who undergo marked strength training regimen develop hypertrophied rotator cuff muscles and tendons from graded exercises of the rotator cuff. On MRI, this hypertrophy is depicted as increased muscle and musculotendon bulk with the intramuscular fat replaced by the hypertrophied muscle fibers. This is the opposite of muscle atrophy. There is extensive evidence in literature of muscle hypertrophy caused by strength training regimens, resulting in increased cross-sectional area of the muscle and thereby its strength.[8]

Conventionally, tendons are described as tissues with very slow metabolism and with a very slow ability to adapt to mechanical loading. However, recent literature has described that these tissues are highly responsive to mechanical loading. Langberg *et al*., 2000, showed that the Achilles and patellar tendon bulk increase acutely and can remain elevated for up to 72 h after a bout of strenuous exercise.[9] Although very few longitudinal studies have examined the effects of exercise training and cross-sectional area of human tendons,[10] biochemically, it has been shown that a coupling mechanism exists between muscle and tendon after exercise due to an increase in protein synthesis in both.[11]

Langberg *et al*., 2000, through their biochemical studies, have shown that eccentric exercise can increase peritendinous type I collagen synthesis.[9] Furthermore, animal models have shown tendon hypertrophy in response to strength training.[12] Kongsgaard *et al*., 2007, reported tendon hypertrophy in humans in response to resistance training, along with depicting the variation in the cross-sectional area of the patellar tendon.[8]

The increased bulk of the rotator cuff muscles and tendons with strength training results in excessive filling of the subacromial space, as shown in Figure 1. Even a small degree of movement could result in impingement of the myotendon and tendons of rotator cuff by the overlying bony/ligamentous arch.

We were able to identify this abnormality in 12 of 58 of our patients during a 1½ year period. All patients were below 40 years of age and reported strength training exercises. On the standard multiplanar MRI of the shoulder utilizing T1 and PD-T2 fat-suppressed sequences, no rotator cuff tear or tendinosis was evident. No subacromial bursitis was noted, as depicted by Figures 2 and 3. A type 1 or type 2 acromion was seen and the acromiohumeral distance was >6 mm. There was no thickening of the coracoacromial ligament.

The only abnormality seen in all cases was marked hypertrophy of the rotator cuff muscles, myotendons, and tendons with resultant increased bulk of these structures, completely filling the subacromial space. The superior surface of the supraspinatus tendon and myotendon was seen closely abutting the undersurface of the acromion, best appreciated on the coronal and sagittal sequences. There was apparent indentation of the superior myotendinous junction of the supraspinatus by the acromion. There was loss of T1 hyperintensity of fat within the muscles of the rotator cuff. This is attributed to the replacement of the fat by the hypertrophied muscle fibers from strength training. Furthermore, the bulky supraspinatus muscle demonstrated an excessive superior convexity in the supraspinatus fossa, best appreciated on the sagittal sequences. The myotendons and tendons were thick and depicted uniform dark T1 and T2 signal. This was attributed to increased tendon bulk, also from strength training.

This pattern results in overfilling of the subacromial space by the rotator cuff myotendons and tendons with secondary compression by the bony and ligamentous walls of the subacromial space, as shown in Figure 4. The pressure and irritation that occur with movement cause symptoms of pain and disability that clinically mimic impingement.

CONCLUSION

Rotator cuff impingement is a common phenomenon occurring with various inlet and outlet abnormalities. We have described a novel phenomenon with 12 of our patients, whereby strength training regimen resulted in hypertrophy rotator cuff muscles, myotendon, and tendon. Subsequently, there was overfilling of the normal subacromial space by the hypertrophied tendons/myotendons, as evidenced by MRI. The overfilling of the subacromial space leads to a secondary impingement of the rotator cuff muscles and tendons, which we have termed "pseudo-impingement." Early detection of this phenomenon in strength trainers can prevent progression to rotator cuff tendinopathy and tears. Early clinical recognition with the help of MRI can reduce the pseudo-impingement related pain and disability by redefining and restructuring the strength training regimens.

Declaration of patient consent

Patient's consent not required as patients identity is not disclosed or compromised.

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Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Michener LA, McClure PW, Karduna AR. Anatomical and biomechanical mechanisms of subacromial impingement syndrome. Clin Biomech (Bristol, Avon) 2003;18:369-79.
2. Fleming JA, Seitz AL, Ebaugh DD. Exercise protocol for the treatment of rotator cuff impingement syndrome. J Athl Train 2010;45:483-5.
3. Bigliani LU, Morrison DS, April EW. The morphology of the acromion and rotator cuff: importance. Orthopedic Trans 1986;10:228.
4. Ling SC, Chen CF, Wan RX. A study on the vascular supply of the supraspinatus tendon. Surg Radiol Anat 1990;12:161-5.
5. Graichen H, Bonel H, Stammberger T, Englmeier KH, Reiser M, Eckstein F, *et al.* Subacromial space width changes during abduction and rotation a 3-D MR imaging study. Surg Radiol Anat 1999;21:59-64.
6. Crass JR, Craig EV, Thompson RC, Feinberg SB. Ultrasonography of the rotator cuff: Surgical correlation. J Clin Ultrasound 1984;12:487-91.
7. Teefey SA, Rubin DA, Middleton WD, Hildebolt CF, Leibold RA, Yamaguchi K, *et al.* Detection and quantification of rotator cuff tears. Comparison of ultrasonographic, magnetic resonance imaging, and arthroscopic findings in seventy-one consecutive cases. J Bone Joint Surg Am 2004;86:708-16.
8. Kongsgaard M, Reitelseder S, Pedersen TG, Holm L, Aagaard P, Kjaer M, *et al.* Region specific patellar tendon hypertrophy in humans following resistance training. Acta Physiol (Oxf) 2007;191:111-21.
9. Langberg H, Skovgaard D, Asp S, Kjaer M. Time pattern of exercise-induced changes in Type I collagen turnover after prolonged endurance exercise in humans. Calcif Tissue Int 2000;67:41-4.
10. Hansen P, Aagaard P, Kjaer M, Larsson B, Magnusson SP. Effect of habitual running on human achilles tendon load-deformation properties and cross-sectional area. J Appl Physiol

(1985) 2003;95:2375-80.
11. Miller BF, Olesen JL, Hansen M, Døssing S, Crameri RM, Welling RJ, *et al.* Coordinated collagen and muscle protein synthesis in human patella tendon and quadriceps muscle after exercise. J Physiol 2005;567:1021-33.
12. Birch HL, McLaughlin L, Smith RK, Goodship AE. Treadmill exercise-induced tendon hypertrophy: Assessment of tendons with different mechanical functions. Equine Vet J Suppl 1999;30:222-6.

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