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Mechanism and Treatment of the Rotator Cuff Tear

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Abstract: Among all the joints in the human body, the shoulder has the highest degree of motion, but its stability is relatively limited. As the population ages more rapidly, rotator cuff tear has become the most affected muscle and joint pain lesions in middle-aged and elderly patients and the prevalence rate is increasing year by year. According to imaging studies, rotator cuff injuries affect 30% of asymptomatic adults over 60 and 65% of asymptomatic adults over 70. The rotator cuff tear made pain to the patients, reduced joint range of motion and stability, joint dysfunction. So, the people more and more attach importance to rotator cuff tear. This paper summarizes in recent years about risk factors, mechanism and the treatment of rotator cuff tear, which hope to accelerate the treatment of diseases, which can made partial or complete layer tears. Due to the diversity of rotator cuff tear classification, future studies should be carried out with specific tear size or tear degree.

Keywords: Rotator cuff tear, risk factors, mechanism, treatment.

1. Introduction

Of all the joints in the human body, the shoulder joint is one of the most vital since it affects both static and dynamic stability. Numerous disorders connected to the shoulder frequently coexist with this relevance. Over-50-year-olds frequently suffer from rotator cuff diseases, especially rips of the supraspinatus muscle. While supraspinatus tears may not always present with symptoms initially, patients can experience pain and limitations in shoulder mobility over time, particularly in abduction and forward elevation, potentially leading to disability.

Currently, tears of the supraspinatus muscle have become a focal point of research. Studies indicate that these tears are often the result of age-related degenerative changes; however, the exact pathophysiological mechanisms underlying supraspinatus tears remain poorly understood. Clinicians are increasingly interested in how to achieve faster healing rates within optimal timeframes. With advancements in arthroscopic techniques, arthroscopic repair of the rotator cuff has become the primary method for treating rotator cuff injuries, including supraspinatus tears. Therefore, this article aims to discuss the risk factors, pathophysiological mechanisms, and intervention strategies related to supraspinatus tears.

2. Risk groups and pathophysiological mechanisms

The causes of supraspinatus tears are diverse. One significant factor is the cumulative damage resulting from repetitive use and aging. Muscle fatigue can induce molecular, mechanical, and structural changes in the tendon, where the progression of accumulated damage leads to fiber rupture

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and ultimately tendon tear. Excessive activity can overload the shoulder, causing impingement and tendon degeneration. Overall, these factors can be categorized into acute and chronic contributors [1-5].

2.1. Acute Factors

Acute impacts are a significant factor contributing to supraspinatus tears, as they can result in muscle tears over a short period. When individuals trip, they often use their arms to brace themselves, reducing the impact with the ground and protecting their heads from injury. Most falls occur inwardly to prevent head trauma, individuals extend their arms for support. In such cases, the supraspinatus and infraspinatus tendons experience considerable stress. When the arm is extended during a fall, it is forcefully adducted at the glenohumeral joint. The force on the arm creates axial loading, which can impinge the supraspinatus tendon against the lateral acromion, leading to tendon rupture.

During falls, the peak impact force on the shoulder can reach three times body weight (BW) when individuals are under physical tension. When attempting to break their fall with their arms, this peak impact force can reach 2.5 times BW. Under these conditions, the peak force exerted by the arm is significantly greater than that on the hip or shoulder, averaging 3.78 times BW. In tests that replicated identical falls using anthropomorphic test dummies, the peak impact force on the shoulder varied between 3.2-10.1 times BW. As a result, when people fall from a standing or walking position, greater forces are anticipated. Acute supraspinatus tears are a common consequence of falls, and patients of any age can experience these tear episodes. Supraspinatus tears can occur in partial or whole thickness when the forces and strains created in the rotator cuff after a fall locally surpass the tensile strength of the tendon fibers [6].

2.2. Chronic Factors

2.2.1. Age

Older adults are also at high risk for supraspinatus tears, with the injuries increasing with the age. As people age, muscle strength declines, and the muscles and tendons of the shoulder undergo degeneration due to prolonged overuse, making them more susceptible to rotator cuff tears. In older individuals, the number of microvessels in the tendons is significantly lower than in younger adults, which predisposes the rotator cuff tissue to fibrous vascular proliferation, fat deposition, atrophy, and calcification—all of which increase the risk of tearing [7].

2.2.2. Overactivity

Individuals who must rely on wheelchairs are at heightened risk for rotator cuff injuries, including supraspinatus tears, particularly due to the effects of their conditions. Their shoulders are often "overused" in daily activities, leading to abnormal and harmful stress patterns that can gradually cause muscle imbalances and degeneration. The act of transferring in and out of a wheelchair places considerable strain on these patients, especially if they are still active and socially engaged. Although wheelchair propulsion can be powered, the transfer process remains challenging and often difficult to coordinate with a "normal" social life. The shoulder experiences pressures during transfers that can be two to three times greater than during propulsion, with forces that are brief, sudden, and intense, increasing the risk of rotator cuff tears. Additionally, wheelchair users often position their hands at a higher level, which can create shoulder stress due to repetitive postures, particularly when lifting heavy objects, resulting in significantly higher stress on the shoulder compared to individuals without disabilities [8].

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2.2.3. Diabetes

The correlation between diabetes and supraspinatus tears has become a prominent area of research. By upregulating pro-inflammatory mediators, hyperglycemia may enhance the risk of tendon rupture and tendonitis. Additionally, high blood sugar levels can cause microvascular dysfunction in various tissues, including the rotator cuff area, ultimately resulting in tendon weakness. However, the role of vascular distribution in rotator cuff diseases remains incompletely understood. Studies have also shown that the structure of collagen in the tendons of diabetic patients changes, which can adversely affect the mechanical properties of the tendons, leading to reduced tendon length. This indicates that diabetes may alter the collagen structure of the supraspinatus, decreasing its mechanical strength and making it more prone to tearing [7].

2.2.4. Hperlipidemia

Some researchers have proposed that hyperlipidemia may play a role in supraspinatus tears. In mouse models, hypercholesterolemia has been shown to increase the likelihood of tendon tears. This may be due to the accumulation of elevated levels of circulating low-density lipoproteins (LDL) in the tendons, leading to fat deposition and infiltration into the rotator cuff tendons, which could increase the risk of rupture or delay healing [8-10].

2.2.5. Hypertension

Additionally, some research suggests that people with hypertension have a higher incidence of supraspinatus tears than people without hypertension (RR, 1.51 [95% CI, 1.16-1.97]). Gumina et al. divided 408 individuals with rotator cuff tears into groups that were hypertensive and non-hypertensive in order to further examine the effect of hypertension on the risk of rotator cuff tears. Through the use of logistic regression analysis, they discovered that there was a substantial correlation between hypertension and a higher chance of tears—a twofold increase for large tears and a fourfold increase for tiny tears. This emphasizes that rotator cuff tears are more common in hypertension people. However, more research is needed to determine the processes via which hypertension causes supraspinatus rips [11].

2.2.6. Smoking

Since nicotine, a component of tobacco, is a vasoconstrictor, smoking is also regarded as a high-risk factor for supraspinatus tears. This is because smoking may worsen relative vascular insufficiency in the rotator cuff, which can result in cellular hypoxia and apoptosis, which further contribute to degeneration. As a result, there is an increased risk of supraspinatus tears, though these associations have not been thoroughly reviewed and compiled in the literature. Additionally, there are other potential causes of supraspinatus tears that remain uncertain, possibly linked to genetic mutations that result in tendon degeneration [12].

3. Treatment

Before the treatment, patients typically undergo simple assessments, such as evaluating joint range of motion and muscle strength. Current treatment options for supraspinatus tears are divided into conservative and surgical approaches. Conservative treatment focuses on improving joint mobility and dynamic rotator cuff strength through physical means, prioritizing muscle exercises to enhance shoulder stability. Given the significant pain associated with these tears, managing pain is crucial, as nearly 99% of patients seek medical attention due to pain. Studies have shown a correlation between pain and increased tear size, making pain control a key component of conservative treatment [13-16].

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For symptomatic rotator cuff tears, one study combined subacromial injections (with a steroid and lidocaine) and intra-articular sodium hyaluronate with shoulder strengthening exercises. Results indicated that 40% of patients experienced complete pain relief, 30% reported pain reduction, and 70% found no impact on daily activities. Additionally, 75% of patients achieved excellent outcomes according to Japanese Orthopedic Association shoulder scoring criteria. Strengthening remaining rotator cuff muscles through targeted exercises has been shown to improve quality of life and joint function, with conservative treatment effectiveness rates for full-thickness tears reported between 73% and 80%. While exercise is statistically significant for pain relief and functional improvement, its effect on shoulder range of motion and strength is less clear [15-17].

Core training is another conservative approach that can enhance shoulder mobility and stability while alleviating pain. A structured rehabilitation program typically includes three phases: Phase 1 (0–3 weeks) focuses on passive range of motion; Phase 2 (3–9 weeks) introduces active exercises within a pain-free range; and Phase 3 (10–12 weeks) emphasizes strengthening [18].

When conservative treatment fails to yield satisfactory results, surgical intervention is often recommended to alleviate pain and improve joint function. Advances in medical technology have enhanced the diagnostic accuracy for supraspinatus tears. Standard surgical methods include open surgery and arthroscopic approaches, with the choice dependent on clinical experience and patient condition. Open surgery offers a wider view, while arthroscopy results in smaller incisions. Common arthroscopic techniques include single-row and double-row fixation methods, with double-row techniques providing more secure fixation. Following surgery, patients typically rest in bed with the injured limb elevated and ice applied to the surgical site [13].

Currently, there is no clear evidence indicating a superior surgical method for higher healing rates. Historical treatment protocols suggest that tears larger than 5 centimeters are classified as massive supraspinatus tears, for which double-row techniques are often employed [13].

4. Postoperative rehabilitation

Postoperative rehabilitation following arthroscopic rotator cuff repair typically includes early rehabilitation training. This training encompasses both active and passive movements of the rotator cuff tendons, along with progressively increasing strength training. Through these exercises, the structure and function of the rotator cuff can improve, facilitating recovery of the shoulder joint. Additionally, rehabilitation helps enhance the coordination and balance of the muscles surrounding the shoulder joint, as rotator cuff tears often lead to muscle dysfunction, resulting in strength imbalances and poor coordination [19,20].

Rehabilitation generally begins on the first day after surgery, focusing on functional exercises for the affected upper limb, passive movements, and active exercises. Patients are guided to perform wrist and elbow mobility exercises under splint immobilization, with regular passive movements of the fingers, wrist, and elbow, gradually increasing the range of motion based on tolerance. Active exercises, primarily focusing on shoulder flexion and abduction, start two weeks post-surgery. The entire early rehabilitation process typically lasts about six weeks [21].

5. Conclusion

The mechanism of the supraspinatus rotator cuff muscle is divided into acute and chronic. Simple falls may lead to acute rotator cuff tears, and fall-related tears are not limited to young people. It can influence all ages people. When the people are falling and trying to cushion, the stress generated in the rotator cuff may locally exceed the tensile strength of the tendon fibers. Hyperlipidemia, hypertension, smoking, and diabetes will all increase the risk of supraspinatus tendon tear of the rotator cuff. So far, the mechanism of supraspinatus tendon tear of the rotator cuff has not been fully

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clarified. The treatment methods for supraspinatus tendon tear of the rotator cuff are divided into conservative treatment and surgical treatment. Surgical treatment is divided into open surgery and arthroscopy. Arthroscopy is further divided into single-row and double-row configurations as well as suture anchors and suture bridge configurations. The doctor's association will determine the treatment plan according to their own experience and the patient's condition. Reasonable postoperative rehabilitation can reduce the recurrence rate of supraspinatus tendon tear of the rotator cuff and accelerate the healing of the supraspinatus tendon.

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