

Treatment Strategies for Rotator Cuff Calcific Tendinitis and Precision Platform

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Abstract. T Shoulder movements are common in our daily life and the shoulder is a crucial body part, because it is the most freely movable. Rotator Cuff Calcific Tendinitis (RCCT), the primary cause of shoulder pain, is a painful shoulder disorder that might lead to pain and shoulder dysfunction. Symptoms include shoulder pain, frozen shoulder, and reduced range of motion. The disorder is caused by calcific phosphate crystal deposits on the rotator cuff, but the pathogenetic mechanism is not clear yet. The disease is very common and might recur even after treatments. This research compiles current, advanced treatments, including conservative treatments and surgery, and their advantages and disadvantages. Based on this, the research develops a platform that fuses diagnosis, treatment, rehabilitation, and computer science to promote individualized treatment by quantitatively analyzing X-rays, providing prescriptions, and monitoring patients' conditions in real time. The platform is conducive to objective diagnosis and better clinical results, and is able to be used to treat other diseases.

Keywords: RCCT, Integrated health monitoring platform, personalized treatment, precise recovery.

1. Introduction

The shoulder has the greatest range of motion of any joint in the human body. Important sections of the shoulder include bones, joints, ligaments, tendons, muscles, nerves, blood vessels, and bursae. Bones include the upper arm bone, the shoulder blade, and the collarbone. The glenohumeral joint is where the ball of the upper arm bone fits into the socket on the shoulder blade. The Acromioclavicular (AC) Joint is where the collarbone meets the acromion. The Sternoclavicular (SC) Joint buttresses the connection of the arms and shoulders to the main skeleton. The scapulo-humeral joint allows the muscles surrounding the scapula to work jointly to keep the socket normally aligned during shoulder movement. Ligament connects bones to bones, while tendons connect muscles to bones. Four tendons connect the Rotator Cuff muscles to the upper arm bone, and they meet to form a tendon named the rotator cuff. The rotator cuff muscle is located outside the shoulder joint, and it functions by assisting the arm to be raised from the side and rotated in many directions. The rotator cuff tendon also stabilizes the shoulder by holding the ball of the upper arm bone tightly in the socket during the upper arm bone. The main nerves of the shoulder that go into the arm run through the axilla under the shoulder, conveying signals between the brain and the muscle. Main blood vessels also run through the axilla, providing the shoulder with a rich blood

supply. The complex structure of the shoulder indicates how difficult life will be when the shoulder is injured.

Rotator Cuff Calcific Tendinopathy (RCCT) is caused by the calcific deposits in the rotator cuff when the calcification extends around the rotator cuff. The pathogenetic mechanism is still being studied. The disease can be divided into three phases: precalcific stage, calcific stage, which is characterized by acute pain, edema, and increasing intratendinous pressure and postcalcific stage. Conventional radiography, Ultrasound, and Magnetic Resonance Imaging can be used as diagnostic tools. Treatments can be categorized into conservative treatments and surgery. The disease is frequent and leads to pain and disability, thus treatment is important to help patients return to normal life [1].

Recent studies on RCCT primarily focus on studying innovative treatments and combining computer science with sport science. One recent study of scholars from the USA and Italy introduces and appraises a game named painting discovery aimed at shoulder rehabilitation. The game guides patients to move their hands to control a target on the screen, and a controller tracks the motion of the hands. In this way, the therapist is able to customize the treatment for the patients based on data in real time. The study shows that the game is not only interesting but also cost-effective, encouraging patients to exercise [2]. Studies conducted by scholars from China integrate traditional Chinese and Western Medicine. For instance, a study conducted in 2025 examines a treatment combining Extracorporeal Shock Wave Therapy (ESWT) and Chinese Herbal Fumigation. Extracorporeal Shock Wave Therapy offers advantages such as short treatment cycles, fewer complications, and low risks, while fumigation therapy can promote blood circulation and resolve blood stasis, enabling better penetration of medication into the skin. Studies have shown that this combined treatment approach enhances clinical efficacy [3].

The incidence and treatment costs of RCCT are high, and severe shoulder pain significantly impacts patients' quality of life. Furthermore, patients often struggle to make informed decisions due to trade-offs between different treatment options. Therefore, the study aims to synthesize current relevant treatment methods and propose personalized assessment and treatment plans to promote precision rehabilitation. The paper aims to develop an integrated diagnosis-treatment-rehabilitation platform that is connected to the mobile applications with monitoring devices, allowing real-time data transmission from the device to the software.

2. Classification and characteristics of treatment methods for calcified tendinitis of the rotator cuff

As a common shoulder disease, calcified tendinitis of the rotator cuff presents numerous challenges to clinical decision-making due to its recurrent nature and diverse treatment options. In April 2005, a patient with persistent pain and discomfort in the right shoulder was diagnosed with this disease. In November of the same year, he underwent arthroscopic surgery to remove calcified deposits. After rehabilitation treatment, shoulder function improved and pain was reduced. However, in November 2009, he sought medical attention again due to the recurrence of calcified deposits. After ineffective extracorporeal shock wave therapy (ESWT), he underwent a second arthroscopic surgery and eventually returned to normal life. This case not only demonstrates the effectiveness of surgical treatment in clearing lesions but also exposes the possibility of disease recurrence and the complexity of treatment options, providing a practical basis for us to systematically explore treatment strategies for calcified tendinitis of the rotator cuff [4]. The treatment methods for calcified tendinitis of the rotator cuff are mainly divided into two categories: non-surgical treatment

and surgical treatment. Each method has its unique mechanism of action, scope of application, and risk-benefit ratio, and clinical selection should be based on the specific situation of the patient.

2.1. Non-surgical treatment

Non surgical treatment is the first-line treatment option for calcified tendinitis of the rotator cuff, suitable for patients with mild symptoms, short course of disease, or intolerance to surgery, including platelet rich plasma (PRP) treatment, bone marrow aspiration concentrate (BMAC) treatment, dry needle therapy, sodium hyaluronate treatment, rehabilitation plan and extracorporeal shock wave therapy (ESWT). The platelet-rich plasma (PRP) treatment method uses the liquid portion of plasma in the blood and platelets with coagulation ability and containing growth factors that promote healing and regeneration of the treatment site. The preparation process of platelet-rich plasma involves extracting a blood sample from the patient, centrifuging the sample to obtain platelets, increasing the concentration of platelets in the plasma, and then injecting the solution into the site of injury. PRP injection can treat various musculoskeletal injuries. The increase in growth factor concentration accelerates the healing process and reduces pain, although the mechanism behind this injection is not yet clear. Previous studies have shown that PRP has significant advantages over other control treatments in medium to long-term treatment, and PRP can effectively improve shoulder function in patients with rotator cuff disease. Although PRP has a wide applicability and low risk, it can also generate some risks and side effects. Patients may experience discomfort, swelling, bruising, redness, and skin irritation at the injection site, which are all normal reactions. Although very rare, if aseptic techniques are not strict, it may lead to infection. Patients who are allergic to the components of the solution preparation are prone to allergic reactions [5]. In addition, the treatment effect is not permanent, so patients may need additional injections.

Bone marrow aspiration concentrate (BMAC) treatment uses the patient's own bone marrow as raw material and obtains the patient's own bone marrow through bone marrow puncture. After the collection of bone marrow aspirates, processing is required, including filtration, sample analysis, two rounds of centrifugation, and final analysis of blood cell count, and then the solution is sterilely injected into the patient's body. This technology is easy to operate, there is no risk of transmission of homologous diseases, and the risk of infection is relatively low. On the contrary, its disadvantage is that there may be pain during the collection process, and red blood cells may have harmful effects when used in the intra-articular environment. There is limited research on the optimal number of BMAC treatments, treatment volume, and injection timing. In addition, once cells in the solution are injected, they may lose control and transform into tumor cells. Therefore, further research is needed on the safety and standardized procedures of this treatment [6].

Dry needle therapy refers to the use of one or more thin monofilament needles inserted into muscle tissue with local functional impairments. The needle does not inject liquid into the injured area and stays in the muscle for a short period of time. The exact duration of stay depends on the treatment site, the number of needles, and the purpose of treatment. Practitioners use a variety of techniques, including deep dry needles, superficial dry needles, dry needles combined with electrical stimulation, in and out techniques, and techniques for inserting needles into muscle tissue around nodules. This treatment can reduce muscle tension, increase blood flow, and relieve pain. This is a safe treatment method, but there are also related side effects. Non-sterile needles can cause infection, and piercing major organs can cause organ damage. In addition, for patients with hemorrhagic diseases, weak immune system, diabetes, epilepsy, lymphedema and vascular diseases, dry acupuncture may not be an appropriate choice. Pregnant women and those who use blood

thinner should also be cautious [7]. Therefore, dry needle therapy is not a universally applicable technique.

Sodium hyaluronate therapy is a substance that simulates the natural presence of hyaluronic acid in joints, playing a role in absorbing friction. The gel or solution is directly injected into the injured part. The dosage varies for different patients. Despite the expected effects, side effects should also be considered, including coughing, difficulty swallowing, dizziness, fever, difficulty breathing, and swelling of eyelids, face, or lips. These phenomena are less common than other side effects and may disappear as patients adapt to the medication without the need for medical intervention. Before making a decision, the risks of receiving the treatment should be considered. For allergy patients, this treatment may be feasible. In addition, research on this drug has only been conducted in adult patients, so special caution is needed when administering medication to the elderly and young children. Meanwhile, there is insufficient research on breastfeeding women to assess the risks to infants [8]. In short, the applicability of this drug is relatively narrow.

A rehabilitation plan is a rotator cuff and shoulder conditioning program that typically includes strengthening the muscles that support the shoulders and stretching the strengthened muscles to maintain shoulder joint stability and restore range of motion. The first step is to engage in 5 to 10 minutes of low-intensity warm-up activities. The next step is stretching exercises, such as internal and external rotation, scapular retraction, lateral stretching, etc. The rehabilitation plan should last for 4 to 6 weeks, with 2 to 3 days per week. Even after recovery, the plan can continue to protect shoulder health for life. However, not every exercise is safe and effective for all patients, so patients must discuss with their therapist and choose the most suitable exercise for themselves [9].

The basis of extracorporeal shock wave therapy (ESWT) is the use of repeated pulses on the injured shoulder, although the mechanism behind this technique is still controversial. Specifically, there are two hypotheses. The mechanical effect hypothesis suggests that ESWT induces calcium sediment fragmentation by increasing the pressure inside the sediment. The molecular effects hypothesis suggests that ESWT accelerates the phagocytosis of calcium deposits [10]. This treatment is not the best choice for patients with acute pain.

2.2. Surgical treatment

When non-surgical treatment is ineffective, surgical treatment becomes an important choice, mainly including arthroscopic surgery and open or small incision repair surgery, which have differences in operation methods, advantages, and risks. Arthroscopic surgery is performed through small incisions, allowing for the use of surgical tools as thick as pencils. Specifically, a fiber optic camera called arthroscopy is used to diagnose and treat joint problems. A thin tube is connected to the camera, and the internal situation of the joint will be displayed on the high-definition video monitor. Extra small incisions are made around the joints to insert surgical tools, and sometimes sterile liquids are used to expand the area around the joints. During the operation, other surgical procedures such as removal of calcified lesions and decompression of the acromion bursa can be performed, which can be seen as an advantage of arthroscopic surgery. The incision will be closed with sutures or tape. However, a long recovery period is required after surgery, which brings inconvenience to patients in returning to normal life. Although arthroscopy allows doctors to see inside the joint without making a large incision and is a safe surgery, the risks may include tissue or nerve damage, infection, and blood clots. The placement and movement of surgical tools and cameras within the joint may cause damage to the joint structure. Surgery lasting more than one hour increases the risk of thrombosis [11]. Open or small incision repair surgery involves making one or more smaller incisions to separate the covered shoulder muscles and repair the shoulder. The field of view of open

surgery is broader, and compared with arthroscopic surgery, the technical requirements for doctors are relatively lower. However, open surgery carries a higher risk of infection and a longer recovery time.

2.3. Comprehensive discussion and prospects for personalized medicine

Based on the characteristics of the cases and various treatment methods mentioned earlier, it can be concluded that the treatment selection of calcified tendinitis of the rotator cuff needs to consider multiple factors comprehensively. The patient's symptoms were successfully improved after the first surgical treatment, but recurred four years later. The ESWT in non-surgical treatment was ineffective, and the patient was able to recover after another surgery. This indicates that although surgical treatment can effectively clear the lesion, there is a possibility of recurrence, and the effectiveness of non-surgical treatment varies among individuals.

Overall, all treatment options have their own advantages and disadvantages, and patients often face strict application standards, making it difficult to choose the most suitable method for themselves. Even if a treatment is chosen, some patients may not be satisfied with the results and require additional intervention, which not only affects their daily life and health but also increases their economic burden. Therefore, integrating artificial intelligence into personalized healthcare has become crucial. With the help of artificial intelligence technology, it is possible to comprehensively analyze the patient's condition, physical condition, treatment history and other information, tailor treatment plans for patients, solve the dilemma of treatment selection, avoid strict application standards, save time, and personalized treatment often brings better clinical results, providing a better path for the treatment of patients with calcified tendinitis of the rotator cuff.

An integrated health monitoring platform is to be designed, fusing an Inertial Measurement Unit (IMU), a Magnetic Inertial Measurement Unit (MIMU), surface electromyography (sEMG) sensors, and optical linear encoders. This platform will be used to measure joint angles, angular velocity, direction of movement and position, analyze the correlation between muscle activation and movement, and capture motion and estimate posture during more complex activities, all designed as a wearable monitoring device. This monitoring device is connected to a software application. This software combines the functionalities of ImageJ and R Software and includes both a doctor-side interface and a patient-side interface. During the diagnostic phase, after the patient has taken an X-ray, the doctor uploads the X-ray images into the software. Through ImageJ's extraction of raw image information and subsequent data analysis via R Software, an objective pathological analysis of calcification foci is generated and sent to the doctor [12]. Following this, in the treatment phase, the software will utilize the pathological analysis from the diagnostic stage along with the patient's basic information to predict the probability of complications and the recovery rate for various treatment methods, ultimately providing a recommended treatment plan that is sent to both the doctor and the patient. In the rehabilitation phase, the patient is required to wear the monitoring device. The device will upload data to the software in real-time, and both the patient and the doctor can view this data. The software will then provide a suggested rehabilitation plan and an estimated recovery time. The doctor will use this data to further optimize the rehabilitation plan.

3. Conclusion

This paper aims to explore how an AI-powered personalized healthcare platform can optimize the clinical outcomes of calcific rotator cuff tendinopathy. The study begins by reviewing the advantages, disadvantages, and applicable conditions of existing treatment options, highlighting that

patients often face challenges in selecting the most suitable therapy, which can lead to recurrence and complications. To address this issue, this paper proposes the development of a system platform based on quantitative AI image analysis: by evaluating patient X-rays, the platform can objectively recommend the optimal treatment plan and monitor patient data in real-time during rehabilitation, thereby achieving personalized treatment and precise recovery. This model is not only applicable to this specific condition but also holds potential for extension to other medical fields. The paper also acknowledges the current limitation of the platform, which is its inability to fully control risks associated with surgical procedures. Consequently, future research will focus on exploring the integration of the platform with surgical robots—where AI generates surgical plans and surgeons operate the robots—ultimately forming a closed-loop intelligent solution that covers the entire treatment cycle.

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