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Jacopo Antonino VITALE, Giuseppe BANFI, Ennio BELLI, Francesco NEGRINI, Antonio LA TORRE

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Title: A 9-months multidisciplinary rehabilitation protocol based on early post-operative mobilization following a chronic-degenerative patellar tendon rupture in a professional soccer player: a case report.

Authors: Jacopo Antonino Vitale[1,*], Giuseppe Banfi [1,2], Ennio Belli[3], Francesco Negrini[1], Antonio La Torre[1,3]

1) IRCCS Istituto Ortopedico Galeazzi, Milan, Italy.

2) Vita-Salute San Raffaele University, Milan, Italy.

3) Department of Biomedical Sciences for Health, Università degli Studi di Milano, Milan, Italy.

*** Corresponding author:**

Jacopo Antonino Vitale, Ph.D.

IRCCS Istituto Ortopedico Galeazzi,

20161 - Milano, Italia

Phone/Fax: +390266214939

e-mail: jacopo.vitale@grupposandonato.it

ORCID ID: orcid.org/0000-0002-7537-079X

ABSTRACT

Background. Isolated patellar tendon rupture (PTR) is the final stage of a long-standing tendon chronic degeneration. PTR requires immediate repair in order to avoid important muscle retraction and tendon fibrosis. The aim was to describe the effects of a rehabilitation protocol after chronic-degenerative PTR on subjective functional outcomes, knee range of motion (ROM), size, and strength in a professional football player.

Case report. A 26-years-old football player who experienced RPT after a 3-year history of proximal patellar tendinopathy. After early surgical repair of the tendon, the athlete underwent a 9-months multidisciplinary rehabilitation program, based on early post-operative mobilization.

Clinical Rehabilitation Impact. Early knee mobilization and gradual controlled load from the second week determined a large increase in flexion ROM, muscular strength and trophy over the weeks by the athlete. Early surgical repair of PTR together with an early knee mobilization program demonstrated excellent results after a 9-months follow-up.

KEYWORDS: PTR, athlete, injury-management, orthopaedics, case study.

INTRODUCTION

Patellar tendon is the distal portion of the knee extensor apparatus and it is located just below the patella, transferring the forces from the quadriceps femoris to the tibial tuberosity. The knee extensor mechanism is heavily involved in most sports, especially in jumping, cutting and landing activities. According to data from International Federation of Football Associations (FIFA), the number of people playing football is close to 270 million. Most injuries (60% - 90%) are located in the lower extremities, particularly involving ankle, knee and thigh, specifically hamstring injuries are the most common football injury together with groin injuries and ankle sprains.[4]

Isolated patellar tendon rupture (PTR) is a rare injury, approximatively 0.68/100.000 per year of all soft tissue injuries,[2] requiring immediate repair in order to avoid important muscle retraction and tendon fibrosis. The few studies in this specific research field showed that isolated PTRs have a prevalence in young (<45 yrs.), active men with a 6:1 gender ratio. The rupture occurs in most cases in the proximal third of the tendon at the insertion with the inferior patellar pole.[3] The rupture of a healthy tendon is extremely rare due to the high loading capacity of the patellar tendon structure. For this reason, PTRs in active population are in most cases the finale stage of a long-standing chronic tendon degeneration called patellar tendinopathy.[3]

The most common mechanism of PTR is a sudden eccentric contraction with the knee flexed (typical change of direction).[3] X-ray and ultrasound (US) can be useful to assess the PTR, but the gold standard is a Magnetic Resonance Imaging (MRI). Once recognised the PTR, surgical repair within 2 weeks is strictly necessary in order to restore the knee extensor mechanism. Subject's history and anamnesis are necessary for surgeons and physiatrists to understand the chronic-degenerative nature of the PTR and to set the best rehabilitation up.[4]

There is a large number of studies describing different surgical techniques and most of them concluded that suture with polydioxanone (PDS) cords reinforce provided good loading capacity allowing early rehabilitation with better outcomes.[4] However, due to the rarity of this potentially invalidating injury, current literature does not provide standardized guidelines or rehabilitation protocols for PTRs for athletes. If on one hand there are enough evidences about the positive results of an early mobilization after surgery, on the other hand specific rehabilitation protocols, regarding applied workload, strength re-training and functional outcomes, are totally lacking. This total deficiency of clear evidences, spurred us to preliminarily describe, through a case study, a 9-months multidisciplinary rehabilitation protocol, based on early post-operative mobilization, and its

effects on subjective functional outcomes, knee range of motion (ROM), size, and strength in a professional football player that suffered PTR.

CASE REPORT

The present case report adheres to the CARE (CAse REporting) structure and reporting Guidelines.[5]

Patient

Before entering the study, the subject gave his written, informed consent and received an explanation of the purpose, methods, risks, and benefits of the protocol. The study protocol was approved by the Institutional Ethics Review Committee of the Università degli Studi di Milano in compliance with current national and international laws and regulations governing the use of human subjects (Declaration of Helsinki II).

The study subject of this case report is a professional football player aged 26 years old (weight 71 kg, height 178 cm, BMI 22.41) who, during an official match in May 2017, performing a change of direction, felt a severe pain in the right knee with subsequent inability to extend the leg and proximal patella shifting. Therefore, injury mechanism was a monopodalic eccentric contraction with a subsequent rapid concentric contraction. Once at hospital, US examination showed complete rupture of the patellar tendon. The orthopaedic surgeon, in his clinical report, highlighted that significant amount of degenerated tendon tissue was observed. Four days after injury, surgical repair was performed with PDS cord augmentation through transosseous tunnels. In two different past MRIs, the reports showed marked thickening of the proximal insertion portion of the tendon (November 2014) and abnormal signal intensity in the proximal third of the patellar tendon, as jumper's knee (September 2015).

Procedures

The subject started the rehabilitation protocol the day after surgery. In Table 1 is summarized the rehabilitation protocol design.

<insert Table 1 about here>

Knee ROM

In our protocol, brace was never locked at 0° of flexion, but it allowed 30° in first two weeks, 45° in third week and 60° in fourth week and it was removed from fifth week on. For passive ROM (p-ROM) the athlete worked daily (3 times a day for 30 minutes) on flexion-extension with a Kinetec (Fisiotek 3000N, RIMEC, Bologna,

Italy), setting the range of movement without exceeding 3-4 Visual Analogue Scale (VAS)[19] pain values, until he reached the maximum machine ROM capacity. The physiotherapist added manual and physical therapy 3/4 times a week. With the increase of p-ROM, exercises for active ROM (a-ROM) were added: heel slides in a supine position, continuing with proprioceptive exercises and flexion-extension tasks for neuromuscular re-training, stationary bike modifying the height of the seat, and hydrokinetic exercises. Full a-ROM (> 140° of knee flexion) was reached in 18th week.

Knee strength

The strength re-training was based on the gradual progression of all types of muscular contraction, namely from isometric to eccentric and plyometric training. The different rehabilitation steps for strength are specified in Table 1.

The subject started with light isometric contractions with no flexion from the 2nd week in order to prevent the negative effect of arthrogenic muscular inhibition (AMI).). From the 4th week on, NMES (Neuro Muscular Electric Stimulation) was included in order to support the voluntary contraction of the subject and to increase the motor units recruited and their contraction intensity In a second phase, along with the gradual load gain, isometric exercises at greater degrees of flexion, light isotonic exercises and hydrokinetic exercises were included, in order to re-establish gradual bipodalic load. In this phase the subject was able to perform some exercises with elastic bands (i.e. leg extensions), light isometric bipodalic squats and stationary bike-cycling at different seat heights and resistances. From the 13th week the athlete started a heavy-slow resistance training and continued with isotonic training progression in both open kinetic chain (OKC) and closed kinetic chain (CKC). An important variable of the progression of the rehabilitation concerned the transition from bipodalic to monopodalic exercises. He also started with light eccentric training such as lateral lunges in minimal degrees of flexion and step up-down eccentric exercise with the injured knee involved. From the 24th week, (the beginning of the last phase of rehabilitation) the athlete increased training workloads, especially eccentric training, resistance training and completed aerobic re-training. More sport-specific exercises were included such as ball-exercises on both artificial turf and/or sand, plyometric training and isoinertial training.

Weight-bearing activities

Once the subject was able to walk safely with one crutch, hydrokinetic exercises were included, reducing the height of the water in order to increase the load. Walking without crutches started in the 11th week. Once walk

was stabilized, running re-training started in 17th week and, at this point, treadmill speed was used for training progression. Whenever the subject was able to run 10 minutes at a certain speed, treadmill speed was raised by 0,5-1 km/h. Load management and walking/running speed are summarized in Table 1, differentiating activities of daily living (ADL) from rehabilitation activities.

Outcome Measures

The following variables were evaluated at different time points:

- Knee ROM; ROM measurement was carried out weekly with a goniometer (Baseline Hi-Res Plastic 12" Goniometer 360 Degree, Bolingbrook, IL, USA). Levers were positioned distally on the external malleolus and proximally on the femoral head, with the fulcrum on Gerdy's tubercle
- Knee strength; measurement of the maximum isometric contraction was performed bilaterally every months, starting from the 15th week of the rehabilitation protocol, using a dynamometer (Sauter FK 1k, Sauter GmbH, Balingen, Germany) positioned with the knee flexed at 90°.
- Thigh circumferences; thigh circumferences were evaluated bilaterally at 15 centimetres superior to the upper patellar margin by a measuring tape (Seca 203 Ergonomic Circumference Measuring Tape, Hamburg, Germany).
- Subjective functional scales; in order to monitor and quantify the rehabilitation progression perceived by the subject, he weekly compiled three validated patient-rated scales: International Knee Documentation Committee Subjective Knee Form (IKDC),[6] Knee Injury and Osteoarthritis Outcome Score (KOOS)[6], and the Lower Extremity Functional Scale (LEFS).[8]

Results

Results and trends for knee ROM, strength, thigh circumferences and functional scales after surgery are shown in Figure 1.

< insert Figure 1 about here>

DISCUSSION

In the present case study, we described for the first time the effects of a 9-month rehabilitation protocol, based on early post-operative mobilization, on knee ROM, strength, size, and on subjective functional variables in a 26 years-old professional football player who suffered a PTR with a longstanding history of insertional tendinopathy.

Most of the PTRs are the finale stage of a long-standing chronic degeneration in which the biomechanical process of the tendon is altered.[9] The typical clinical presentation of tendinopathies relates to a localized chronic pain condition which may lead to tendon rupture, the latter attributed to mechanical weakness. In this context, Fu et al[9] proposed a "3-stage theory" trying to decipher and better explain the pathogenesis of a tendinopathy. In stage 1, overuse and repetitive injury trigger healing responses with the possibility for the tendon to repair itself. In stage 2, healing responses failed to repair collagenolytic injuries and pain become significant inducing the subject to undergo various conservative treatments, such as nonsteroidal anti-inflammatory drugs (NSAIDs). Finally, at stage 3, a series of pathological changes occur in the tendon causing either severe pain or mechanical weakness with or without pain that can lead to rupture.[9]

Over the years, different types of surgical repair have been described and evaluated.[3,4] To date, suture of the ruptured tendon with PDS cord augmentation seems to be gold standard for this kind of injury.[4] In addition, this type of repair ensures from the first post-operative phases a ROM of 60-90° flexion, allowing a rehabilitation based on early mobilization. For this reason, while traditional methods have employed full knee immobilization for 6-10 weeks, there has been an increased trend towards early mobilization linked to lower rates of joint stiffness, arthrofibrosis and muscular atrophy.[4] Therefore, to set up the best rehabilitation protocol for the athlete, we immediately started with early mobilization for ROM recovery in order to avoid the aforementioned common long-term problems.[4]

We registered greater improvements in ROM, strength, size, and subjective functionality, at different time points, compared with data of previous similar studies.[10]

Very similar trends between ROM progression and IKDC, KOOS, and LEFS scores were observed. For what concerns the timing of the weight-bearing load, studies are very few and basically divided in two indications: full weight-bearing in extension from the first day and higher protection for long periods.[10] A tendon with a previous insertional tendinopathy is a structure that has lost its adaptive ability to load and a PTR of chronic-degenerative nature needs a longer and more cautious rehabilitation protocol.[10] For this reason, we decided to avoid an aggressive approach regarding weight-bearing and applied load. Hydrokinetic training was extremely useful for load management and knee ROM progression.

An important factor contributing to weakness and atrophy of the quadriceps after a knee injury is AMI, object of lot of studies in the sport scientific literature nowadays. As it can be clearly seen in Figure 1 (panel A), quadriceps strength of the injured limb gradually returned to the contralateral limb values over the weeks. The thigh circumferences have been constantly evaluated with the aim to report the gradual reduction of the

difference between right and left thigh week after week. During the rehabilitation protocol, the subject had no complication of any kind and he is now continuing his return to play process. Despite the novel information provided, the present investigation has several limitations. A case study is not sufficient to provide clear evidences of a rehabilitation protocol for specific orthopaedic issues, e.g. the PTR of an athlete. Longitudinal randomized controlled trials, with large cohorts of patients and based on different rehabilitation treatments, are needed in the future to confirm these preliminary findings.

CONCLUSIONS

To our knowledge, this is the first case study describing in detail, starting from the day after-surgery, a multidisciplinary rehabilitation process of a professional football player that suffered a PTR. Based on these preliminary findings, we observed that early surgical repair of PTR together with an early knee mobilization program had positive results after a 9-months follow-up. Immediate surgical repair and mobilization positively affects knee ROM, its function, and muscle strength. We finally underline again the need for further studies of greater evidence for this non-common clinical case.

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FIGURE LEGENDS

Figure 1. Results for knee strength (panel A), ROM (panel B), functional scales (panel C), and thigh circumferences (panel D) over the weeks of the 9-months rehabilitation protocol. Abbreviations: IKDC, International Knee Documentation Committee Subjective Knee Form[6]; KOOS, Knee Injury and Osteoarthritis Outcome Score[7]; LEFS, Lower Extremity Functional Scale[8].

TABLE 1. Rehabilitation protocol design following PTR.

<table>
<tr><th colspan="37">REHABILITATION TIMELINE</th></tr>
<tr><td rowspan="2">STRENGTH RETRAINING</td><td rowspan="2">P.O.L.I.C.E.</td><td colspan="4">Rehabilitation guidelines
(1st – 6th week)
• Isometric training;
• Light NMES (> 4 w);
• Physical therapy;
• P-ROM w/ a Kinetec.*</td><td colspan="6">Rehabilitation guidelines
(7th – 12th week)
• Isometric training (greater ROM);
• Light isotonic training;
• NMES w/ greater ROM;
• Walk w/o crutches (> 11 w);
• Hydrokinetic Training.</td><td colspan="12">Rehabilitation guidelines
(13th – 24th week)
• Heavy-slow resistance training;
• Isotonic training progression (OKC vs CKC) w/ or w/o NMES;
• Light eccentric training;
• Increased walking speed on treadmill.</td><td colspan="14">Rehabilitation guidelines
(> 25th week)
• Increased training workloads;
• Eccentric training progression;
• Sport-specific training (different surfaces);
• Plyometric training;
• Isoinertial training.</td></tr>
<tr><td colspan="4">Exercise examples
• Isometric contraction w/ a pillow under the knee.
• Starting from week 4 w/ NMES;
• Tecar and manual therapy.</td><td colspan="6">Exercise examples
• Single leg lifts;
• Leg extension w/o resistance;
• Stationary bike at different resistance and seat height;
• Light bipodalic leg press;
• Isometric squat 30-45° flex;
• Hydrokinetic exercise.</td><td colspan="12">Exercise examples
• Isometric back squat 90° w/ NMES and load symmetry evaluation;
• Step up-down progression;
• Lateral lunges max 45°;
• Light monopodalic leg press in full ROM;
• Uphill treadmill walk w/ or w/o weighted vest.</td><td colspan="14">Exercise examples
• Heavy leg press and step up-down workload progression;
• Unstable surfaces run and agility exercises;
• Complete aerobic and strength training;
• Return to play tests.</td></tr>
<tr><td>Run Speed
(km/h)</td><td colspan="5">NO</td><td colspan="5">< 5,5</td><td>5,5</td><td>6</td><td>7</td><td>8</td><td>8,5</td><td>9</td><td>10</td><td colspan="5">> 11</td></tr>
<tr><td>Rehabilitation Load
(percentage)</td><td>NO</td><td colspan="4">10-30%</td><td colspan="4">30-60%</td><td colspan="4">50-80%</td><td colspan="4">100% →</td></tr>
<tr><td>ADL Load
(percentage)</td><td>NO</td><td colspan="2">NO</td><td colspan="3">10-30%</td><td colspan="3">50%</td><td colspan="3">70-90%</td><td colspan="3">100% →</td></tr>
<tr><td>ROM
(degrees)</td><td>37</td><td>47</td><td>56</td><td>62</td><td>67</td><td>74</td><td>87</td><td>90</td><td>93</td><td>106</td><td>108</td><td>114</td><td>118</td><td>123</td><td>125</td><td>128</td><td>140</td><td>140</td><td>141</td><td>143</td><td>143</td><td>143</td><td>140</td><td>140</td><td>140</td><td>148</td><td>147</td><td>147</td><td>149</td><td>145</td><td>144</td><td>148</td><td>143</td><td>143</td><td>147</td></tr>
<tr><td>Weeks</td><td>1</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21</td><td>22</td><td>23</td><td>24</td><td>25</td><td>26</td><td>27</td><td>28</td><td>29</td><td>30</td><td>31</td><td>32</td><td>33</td><td>34</td><td>35</td></tr>
<tr><td></td><td colspan="2">1w</td><td colspan="4">2-6 w</td><td colspan="4">6-12 w</td><td colspan="12">12-24 w</td><td colspan="14">>6 M</td></tr>
</table>

Abbreviations: PTR, patellar tendon rupture; ROM, range of motion; P-ROM, passive range of motion; ADL, activities of daily living; P.O.L.I.C.E., protection, optimal load, ice, compression, elevation; NMES, neuro-muscular electric stimulation; OKC/CKC, open/closed kinetic chain. * Fisiotek 3000N, RIMEC, Bologna, Italy.