ABSTRACT

Purpose. To evaluate the stages of patellar tendon graft remodelling using magnetic resonance imaging (MRI) after anterior cruciate ligament (ACL) reconstruction with or without platelet-rich plasma (PRP) injection.

Methods. 98 patients aged 18 to 65 years with complete rupture of the ACL were randomised to undergo reconstruction with the autologous patellar tendon grafts with or without PRP injection. For the PRP group, 8 ml of PRP was obtained in the surgery room and was percutaneously injected into the suprapatellar joint after portal suture. MRI was obtained at months 4, 6, and 12. Remodelling stages of the grafts were classified as hypointense, mildly hyperintense, moderately hyperintense, severely hyperintense, and diffusely hyperintense by a radiologist blinded to treatment allocation.

Results. More patients in the PRP group than controls attained higher stages of remodelling at month 4 (p=0.003), month 6 (p=0.0001), and month 12 (p=0.354).

Conclusion. PRP enabled faster remodelling of patellar tendon grafts.

Key words: anterior cruciate ligament reconstruction; patellar ligament; platelet-rich plasma; transplantation, autologous

INTRODUCTION

Anterior cruciate ligament (ACL) tears are usually treated surgically if the rupture is complete or causes knee instability. The use of an autologous patellar tendon graft is a controversial but recognised treatment for athletes.1 Platelet-rich plasma (PRP) or plasma rich in growth factors (PRGF) has been approved in the US and European Community for promotion of tissue regeneration in bone, cartilage, ligaments, and tendons in vitro, in vivo, and in humans.2-8 The remodelling process of the graft takes about one year and correlates with its homogeneity on magnetic resonance imaging (MRI) and its tension.9 Remodelling stages can be classified
histologically\textsuperscript{10–12} or using MRI.\textsuperscript{13} Although there are protocols for the use of PRP to promote early functional recovery,\textsuperscript{14} no benefit was noted at the time of complete remodelling.\textsuperscript{15} We evaluated the stages of patellar tendon graft remodelling using MRI after ACL reconstruction with or without PRP injection.

**MATERIALS AND METHODS**

Between January and July 2009, 100 patients aged 18 to 65 years with complete rupture of the ACL were randomised to undergo reconstruction with autologous patellar tendon grafts with or without PRP injection. Patients with previous surgery on the same knee or any disease/condition that precluded use of PRP (neoplasm, hyperuricaemia) were excluded. Informed consent was obtained from each patient. The ethics committee of the hospital approved the study. Surgery was performed by the same team for both groups. Rehabilitation was standardised.

Knee arthroscopy was performed under spinal block. After synovectomy and debridement, the patellar tendon graft was obtained through an anterior patellar approach. The tibial tunnel was created with a guide at 55º with an articular exit behind both the anterior tibial spine and the anterior horn of the lateral meniscus. The femoral tunnel was drilled via an anteromedial portal 10 mm from the posterior cortex of the femur. The graft was placed at 10 or 2 o’clock. Both bone plugs were 9 mm in diameter. Hydroxylapatite screws were used as anchors in the femur and tibia.

For the PRP group, 8 ml of PRP was obtained in the surgery room using a PRGF technique (BTI Systems Vitoria, Spain),\textsuperscript{16} and percutaneously injected into the suprapatellar joint after portal suture. Drainage was kept closed for 6 hours.

Postoperatively, the knee was immobilised with 2 plaster splints. Patients were discharged after drainage removal at day 2. At week 1, the splints were removed and passive mobilisation of the knee was allowed. At week 4, progressive weight-bearing ambulation was allowed as pain tolerated. Pool exercises were started at week 6, outdoor cycling at month 3, progressive running at month 4, and return to unrestricted sporting activities at month 6.

MRI was obtained 4, 6, and 12 months after surgery. Remodelling stages of the grafts\textsuperscript{13} were classified by a radiologist blinded to the treatment allocation as hypointense, mildly hyperintense, moderately hyperintense, severely hyperintense, and diffusely hyperintense (Fig.). The 2 groups were compared using the Mann-Whitney \textit{U} test. A \textit{p} value of <0.05 was considered statistically significant.

**RESULTS**

One patient in each group did not complete all MRI protocols and were excluded from the analysis. The PRP and control groups did not differ significantly in terms of age, comorbidities, sex, height, weight, and postoperative swelling and complications. More patients in the PRP group than controls attained higher stages of remodelling at month 4 (\textit{p}=0.003), month 6 (\textit{p}=0.0001), and month 12 (\textit{p}=0.354) [Table].

**DISCUSSION**

ACL reconstruction enables stabilisation and

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**Figure** Five stages of patellar tendon graft remodelling on magnetic resonance imaging: (a) hypointense (same intensity as posterior cruciate ligament [PCL]), (b) mildly hyperintense (with <1/3 hyperintense zones), (c) moderately hyperintense (with <2/3 hyperintense zones), (d) severely hyperintense (with >2/3 hyperintense zones), and (e) diffusely hyperintense (with same intensity as PCL).
biopsies in humans show <30% tissue necrosis 3 to 8
weeks after patellar ligamentoplasty, and thus early
rehabilitation is recommended.23

MRI is the most accurate, non-invasive tool for
diagnosing acute ACL injury24 and evaluating its
reconstruction,25 particularly when clinical assessment
is difficult.26 MRI has been used to evaluate stages
of ACL healing after different grafting techniques.27
There are 4 remodelling stages based on the signal
intensity of the graft.13 Grade I indicates that the graft
is homogeneously hypointense, indistinguishable
from the posterior cruciate ligament and patellar
ligament. Grade II indicates >50% normal ligament
with patches yielding increased signals. Grade III
indicates <50% normal ligament with >50% yielding
high intensity. Grade IV indicates diffuse, increased
signal intensity of the graft with no areas of normal
ligament. In the current study, 5 remodelling stages
were used, as remodelling of the graft was evaluated
at 1/3, between 1/3 and 2/3, at 2/3, at >2/3, and
complete remodelling.

The use of biological techniques for tissue
repair has increased, particularly with respect to
the application of autologous PRGF.7,14,28 There are
different techniques to obtain PRGF, and thus its
effectiveness differs significantly.29,30 The tissue repair
process involves angiogenesis, tissue proliferation,
and extracellular matrix. The remodelling process is
combined with the mechanical stress to the tendon
or ligament.7 PRGF contains a mixture of mediators
participating in the natural repair process. They
include transforming growth factor-1 (TGF-1), platelet-
derived growth factor (PDGF), vascular endothelial
growth factor (VEGF), epithelial growth factor (EGF),
hepatocyte growth factor (HGF), and insulin-like
growth factor (IGF-I).7 PDGF, TGF-1, and some TGF
subtypes are responsible for the acceleration of tissue
healing and increased graft tension.14 PRP stimulates
the proliferation and collagen production in cultured
human tenocytes,4 and increases collagen type I and
III in flexor tendons in horses8 and in vivo.31 TGF-1,
TGF-2, and TGF-3 increase tensile force resistance
by 65%.27 In vivo animal studies have shown a 30%
increase in resistance in Achilles tendons3 and rotator
cuff tendons.32 TGF and EGF increases collagen
and fibroblast synthesis by 40% in canine grafts.33
PDGF-BB improves the biomechanical properties
of the medial collateral ligament in vivo in the early
stages.34 PRGF enables greater mean area tensioning
with superior biomechanical properties after ACL
elongation.5 PRGF enables faster recovery in Achilles
tendon injuries.7 PRP significantly improves pain
and function 2 years after cuff repair surgery.8 PRGF
reduces the recovery time by 27% for the medial

<table>
<thead>
<tr>
<th>Graft remodelling</th>
<th>No. of patients</th>
<th>p Value</th>
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<tbody>
<tr>
<td></td>
<td>Platelet-rich plasma group</td>
<td>Controls (n=49)</td>
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<tr>
<td>Month 4</td>
<td></td>
<td></td>
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<tr>
<td>Hypointense</td>
<td>4</td>
<td>7</td>
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<td>Mildly hyperintense</td>
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<td>19</td>
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<tr>
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<td>20</td>
<td>12</td>
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<tr>
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<td>9</td>
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<tr>
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<td>2</td>
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<tr>
<td>Month 6</td>
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</tr>
<tr>
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<td>6</td>
</tr>
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<tr>
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</table>

Table Graft remodelling at months 4, 6, and 12 between the 2 groups
collateral ligament in soccer players.\textsuperscript{1} Autologous PDGF improves tension, resistance and collagen quality, and increases remodelling rates.\textsuperscript{35} PDGF enables greater remodelling for the patellar graft at 6 months (assessed by MRI) without an increased tibial tunnel diameter.\textsuperscript{36} Based on MRI assessment, remodelling is 48% faster in grafts treated with PRGF.\textsuperscript{14} Nonetheless, no significant difference is noted in ligament grafts with or without PRGF one year later.\textsuperscript{15}

One limitation of the current study was that only one radiologist evaluated the MRIs. Evaluation by more than one radiologist could have measured the inter-observer reproducibility. In addition, correlation between remodelling stages and clinical outcome scores was not evaluated, so more appropriate rehabilitation protocols could not be established.

DISCLOSURE

No conflicts of interest were declared by the authors.

REFERENCES


