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Retrospective Study

Complex knee injuries treated in acute phase: Long-term results using Ligament Augmentation and Reconstruction System artificial ligament

Gliatis J *et al.* Early treatment of complex knee injuries

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Abstract

AIM

To present the long-term results of complex knee injuries, treated early using the Ligament Augmentation and Reconstruction System (LARS) artificial ligament to reconstruct posterior cruciate ligament (PCL).

METHODS

From September 1997 to June 2010, thirty-eight complex knee injuries were treated, where early arthroscopic PCL reconstructions were undergone, using the LARS (Surgical Implants and Devices, Arc-sur-Tille, France) artificial ligament. Exclusion criteria were: late (> 4 wk) reconstruction, open technique, isolated PCL reconstruction, knee degenerative disease, combined fracture or vascular injury and use of allograft or autograft for PCL reconstruction. Clinical and functional outcomes were assessed with IKDC Subjective Knee Form, KOS-ADLS questionnaire, Lysholm scale and SF-12 Health Survey. Posterior displacement (PD) was measured with the Telos Stress Device.

RESULTS

Seven patients were excluded; two because of co-existing knee osteoarthritis and the remaining five because of failure to attend the final follow-up. The sample consisted of 31 patients with mean age at the time of reconstruction 33.2 ± 12.5 years (range 17-61). The postoperative follow-up was on average 9.27 ± 4.27 years (range 5-18). The mean average IKDC and KOS scores were 79.32 ± 17.1 and $88.1 \pm 12.47\%$ respectively. Average PD was 3.61 ± 2.15 mm compared to 0.91 ± 1.17 mm in the uninjured knees (one with grade 1 + and two with grade 2 +). Dial test was found positive in one patient, whereas the quadriceps active drawer test was positive in three patients. None was tested positive on the reverse-pivot shift test. The range of motion (ROM) was normal in thirty knees,

in comparison with the contralateral one. There was no extension deficit. Osteoarthritic changes were found in three knees (9.6%).

CONCLUSION

Early treatment of complex knee injuries, using LARS artificial ligament for PCL reconstruction sufficiently reduces posterior tibia displacement and provides satisfactory long-term functional outcomes.

Key words: Complex knee injuries; Posterior cruciate ligament; Acute reconstruction; Ligament Augmentation and Reconstruction System

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Core tip: Complex knee injuries pose a difficult problem while the treatment remains controversial. There are only few studies with long-term follow-up and with homogenous sample, regarding the timing of operation, the type of the graft and the type of reconstruction. In our study with a long-term follow-up, we have operated all the patients in the acute phase, using a standardized protocol regarding the technique, the type of the graft and the postoperative rehabilitation. Furthermore we have excluded the knee dislocations with vascular injuries, since these injuries have a different prognosis and they consist a separate category.

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INTRODUCTION

Although most complex knee injuries are thought to occur due to a knee dislocation, in real practice a complete knee dislocation is very rare. Almost all complex knee injuries involve either the anterior cruciate ligament (ACL) and/or posterior cruciate ligament (PCL). This may be combined with injury to the medial knee structures and/or posterolateral corner structures of the knee. “Benign knee dislocation”, described by Wascher *et al*^[1] features isolated knee injury with mild or no neurovascular compromise and intact bony structure. Controversies also exist regarding various parameters, including early *vs* delayed surgery, type of reconstruction technique being chosen and postoperative rehabilitation program^[2,3]. Very few studies exist with long term follow-up, whilst most of them include cases with complex injuries and true dislocations being classified within the same category.

Amongst the controversies regarding reconstruction of the multiple-injured knee is the choice of PCL graft tissue and the timing of the operation^[4]. Posterior cruciate ligament is considered the primary restraint to posterior translation of the knee and the central stabilizer of the knee^[5-8]. The incidence of PCL injuries is lower than that of ACL, occurring in approximately 3.4% to 20% of all knee ligament injuries^[9]. PCL injuries are presented either as isolated tears or combined with other knee ligament injuries. Multiple knee ligament injuries usually need surgical treatment^[10,11]. Despite the variety of operative techniques, PCL reconstruction still remains a challenge^[10,12,13]. Autografts like Patella tendon (Bone-Tendon-Bone), Hamstrings and Quadriceps tendon or allografts like Achilles tendon, Anterior and Posterior Tibialis tendon are the most commonly used grafts^[4]. Artificial grafts are rarely indicated because of their previous failure in ACL reconstruction^[14-16]. The new generation artificial ligaments offer the advantages of less surgical time, absence of donor site morbidity, avoidance of possible spread of diseases (like Hepatitis C, HIV or knee infection), and faster postoperative rehabilitation^[4,17-21].

As far as the timing of the operation is concerned, previous studies have stress out the risk of arthofibrosis after early treatment^[22,23]. However in other reports, there is evidence that early reconstruction, in the first 4–6 wk usually provides better results compared to delayed reconstruction^[2,24], which could be explained by the good healing capacity of the early ruptured PCL^[25-29]. The limit of early treatment though arbitrary is considered 3 wk. Recently Fanelli *et al*^[3] set the limit of early reconstruction in six weeks long.

In our retrospective study we have included patients with complex knee injuries being treated acutely and followed-up long-term, utilizing a standardized treatment protocol. Early (during 4 wk post injury) PCL reconstruction using an artificial ligament as a temporary restraint to posterior translation of tibia, allows the PCL remnants to heal^[26,30-34] and can give satisfactory early and long-term results concerning posterior stability. In addition the augmentation of the posterolateral corner reconstruction allows the repaired soft tissues to heal in the correct position. We thus, retrospectively present the results of complex knee injuries treated in the early post-injury period using the artificial ligament LARS (Ligament Augmentation Reconstruction System)^[36,37,38] to reconstruct PCL. The purpose of this study was to post-operatively assess the stability and clinical outcomes of the knee in mid-term to long-term follow-up, and to identify the progress of any degenerative changes in acutely operated knees.

MATERIALS AND METHODS

Sample

Multiple ligament knee injuries where PCL was reconstructed with LARS artificial ligament were retrospectively studied. The study period was from 1997 to 2010. Thirty-eight operations were undergone in this period. Inclusion criteria were the early arthroscopically-assisted, multiple ligament reconstruction, always including single bundle PCL reconstruction with LARS artificial ligament. Exclusion criteria were the open technique, the use of allografts or autografts such

Hamstrings or Patella tendon for PCL reconstruction, the isolated PCL reconstruction, the presence of degenerative knee disease and the concomitant fracture or vascular injury that could influence the postoperative rehabilitation program. All patients were operated in the first four weeks after injury, which is the elapsed time to consider an injury as an acute one (Table 1).

Graft selection

The graft used for PCL reconstruction was the LARS (Ligament Augmentation and Reconstruction System, Surgical Implants and Devices, Arc-sur-Tille, France) artificial ligament, made of polyethylene terephthalate. LARS is a system of artificial ligament devices used for ACL, PCL, PLC (posterolateral corner) reconstructions and also Achilles tendon ruptures and acromioclavicular joint injuries^[18,19,36,37,39]. We have used PC 80 in our cases.

Operative technique

All the operations were performed by the two senior authors, which were experienced in multiple ligament reconstructions. Under general anesthesia in supine position, a tourniquet was applied to the affected limb without being inflated. The foot of the operated leg was seated on a post over the operative table with a lateral support to maintain the knee in 90° of flexion. Leg position adjustments were possible. We used fluids with gravity flow and not a pump. An image intensifier was necessary in the theatre. In all cases, we performed a routine arthroscopic examination of the knee joint through the standard anterolateral and anteromedial portals. These portals were made immediately adjacent to the lateral and medial borders of the patellar tendon and 1 cm above the joint line to allow an easy passage of an arthroscope through the intercondylar notch to provide access to PCL tibial attachment. In PCL injuries, it is easier for the arthroscope to pass from the anterolateral portal to the posteromedial compartment through the intercondylar notch. In cases of meniscal or cartilage injury, if debridement was

needed, the medial portal was used as well. Posteromedial portal was not used. Initial intra-articular bleeding was controlled with the aid of intermittent tourniquet inflation. A thorough evaluation of the intra-articular injuries was performed. The meniscal and cartilage injuries were treated first, either with fragments removal or meniscal repair. In all cases PCL was reconstructed, first of all injured ligaments, with LARS artificial ligament. The PCL remnants were always left intact and the tibial tunnel was created first, under image intensifier control (Figure 1). With the LARS instrument there was no need to debride the tibial PCL attachment. Then the femoral tunnel was created aiming just inferior to the native anterolateral bundle attachment of the PCL. The graft was passed afterwards through the tunnels with the aid of flexible wires, leaving the functional part of the graft inside the knee joint. The femoral side was fixed first and the normal step off was restored under image intensifier before the fixation of the tibial side with one screw and one staple. In cases of coexisting ACL rupture, we reconstructed the ligament in the early cases with LARS artificial ligament in the first 12 cases, while in the other 13 cases we used Hamstrings tendons. Posterolateral instability (PLI) was detected clinically with increased external rotation (Dial test) and arthroscopically with the “drive through sign” in 9 cases. We reconstructed posterolateral corner (PLC) addressing the popliteal and popliteo-fibular ligament (Warren procedure)^[35,40]. In all cases we used Hamstrings tendons from the contralateral knee to augment the repaired PLC structures. In none of the cases MCL reconstruction was necessary^[41]. Postoperatively we used continuous passive motion (CPM) from day one. The patients were allowed to partial weight-bear for 6 wk and gradually to full weight-bear up to two months. Postoperatively conventional functional braces were utilized^[20, 21].

Evaluation

All patients were assessed clinically and functionally in an outpatient office by an

independent observer who was an appropriately trained senior resident. Clinical evaluation included Lachman and reverse-Lachman test, Anterior and Posterior Drawer tests (grading: 1 +: 0-5 mm, 2 +: 5-10 mm, 3 +: > 10 mm anterior or posterior translation respectively), Quadriceps Active Drawer test, Dial test for PLI and Varus-Valgus stress tests (grading I: 0-5 mm, II: 5-10 mm, III: > 10 mm opening) for collateral ligaments' assessment^[42]. The functional outcome was assessed with ROM evaluation, KOS-ADLS score and IKDC Subjective Knee Form, while Lysholm knee scoring, and SF-12 Health Survey completed the clinical outcomes^[43-47]. The examiner used the Telos Stress Device to evaluate the posterior displacement of the injured knee in comparison to the contralateral healthy one^[48,49]. A lateral x-ray imaging was performed in 90° of knee flexion under a standard anteroposterior force of 150N from Telos Stress Device (Figure 2). The standard force is widely accepted since 80N are adequate to induce posterior displacement of the tibia, while a greater than 180N force will cause pain and muscle contraction, influencing the reliability of measurements^[50]. The total posterior tibial translation was measured and the side to side difference between normal and affected knee was compared during the force applied and not^[50-53] (Figure 3). Arthritis was assessed by AP radiographs. Arthritis was rated as either present or absent based on joint space narrowing and/or the presence of osteophytes. This methodology is similar to that used in the Kellgren and Lawrence (KL) grading system^[54]. Patients without evidence of osteoarthritis would be considered (KL) Grade 0 to 1, whereas patients with radiographic evidence of osteoarthritis would be considered (KL) Grade 2 to 4.

RESULTS

Thirty-eight patients in total over the 17 years' period sustained a complex knee injury including PCL rupture and underwent a reconstruction of PCL with LARS artificial ligament. From these, two patients were excluded because of co-existing knee osteoarthritis, while five more did not manage to attend the final follow-up.

So, the final sample consisted of 31 patients. From the 31 patients, 27 were males and 4 females. From the reconstructed knees 20 were right side and 11 left. The mean age at the time of reconstruction was 34.5 (\pm 12.5) years (range 17-61). The average time from injury to surgery was 2.67 (\pm 1.24) wk (range 1-4) and the mean time of postoperative follow-up was 9.2 (\pm 4.27) years (range 5-18), (Table 1). From the 31 cases, 24 were motor vehicle accidents (MVA) and 7 were sport injuries and falls (Table 1). All patients were examined clinically (clinical examination) functionally (with functional outcome questionnaires) (Table 2), and radiologically with the Telos stress device (Table 3).

Time interval between injury and operation

Three patients (8.8%) were operated during the first week ($< 1/52$); specifically two patients were operated three days post-injury and one patient on the accident day. Also five patients (17.6%) were operated 1 wk ($1/52$) after the trauma and six patients (17.6%) 2 wk ($2/52$) after their accident, respectively. Five patients (17.6%) underwent operation three weeks ($3/52$) post injury, while twelve patients (38.2%) were treated four weeks ($4/52$) after injury.

Functional scores and clinical findings

The mean KOS-ADLS score (Knee Outcome Survey - Activities of Daily Living Score) was 88.1% (\pm 12.47). Twenty-two patients (70.9%) had score greater than 60/70 and two of them (6.4%) reached the absolute 70/70, indicating excellent functionality. Only one patient (3.2%) had score of less than 35/70. The mean IKDC (International Knee Documentation Committee) Subjective Knee Form was 79.32 (\pm 17.1). Twenty patients (64.5%) reached 70/87 score and above but four patients (12.9%) pointed a score lower than 50/87.

The evaluation according to the Lysholm knee scoring revealed excellent (95-100) results for ten (32.2%) patients, good (84-94) for sixteen (51.6%), fair (65-83) for three (9.6%) and poor (< 64) for only two (6.4%) patients (Table 2). Regarding

the SF-12 Health Survey, all patients except three declared very satisfied from the postoperative outcome in both physical and mental health fields (ranging from 30.8-56.6 and 33.8-62.5 respectively), and further indicated that if again needed, they would undergo the same procedure under the same circumstances (Table 3). The posterior drawer test was positive (grade 2 +) in six ($n = 6$) patients, the anterior drawer test was positive in three ($n = 3$) (one with grade 1 + and two with grade 2 +), the varus stress test in five ($n = 5$) (three with grade I and two with grade II) and the valgus stress test in three ($n = 3$) patients (all with grade II). The dial test was found positive ($> 15^{\circ}$ side to side difference) in one ($n = 1$) patient, whereas the quadriceps active drawer test was positive in three ($n = 3$) patients. None was tested positive on the reverse-pivot shift test. The range of motion (ROM) was normal in thirty knees, in comparison with the contralateral one, with a 0° - 121.2° (± 10.14) average flexion arc and had no extension deficit. Only in one knee there was a limitation of ROM: 0 - 90° .

Radiographic evaluation

The evaluation of knee x-rays (AP weight-bearing-standing) revealed a medial joint space narrowing (> 2 mm in comparison with lateral joint space) in three ($n = 3$) patients; in a 66 year old woman at the last follow-up, 15 years postoperatively with (KL) grade 3 (Figure 4), and in two men 64 and 54 years old, 8 and 15 years after operation, respectively both with (KL) grade 2. The remaining twenty-eight ($n = 31$) patients had no radiographic findings of joint space narrowing (KL grade 0 or 1). The mean tibial posterior displacement of the operated knees as measured with the Telos Stress Device was 3.61 (± 2.15) mm. The value for the normal contralateral knees was 0.91 (± 1.17) mm respectively. Twenty-five patients (80.6%) were found with posterior translation of less than 5 mm (Grade I) and six patients (19.3%) with posterior displacement in the range 6-10 mm (Grade II). No one patient was classified in the group of 11-15 mm or greater than 15 mm (Grades III and IV, respectively) (Table 3).

DISCUSSION

In our study we treated complex knee injuries in the acute phase, at four weeks' time, reconstructing PCL with LARS artificial ligament in all our cases. The clinical outcome was satisfactory in most of the cases long-term. The rate of posttraumatic arthritis was very low, too. Most of our patients in this study maintained a good clinical outcome in the long-term follow-up. We assessed the stability with the Telos Stress Device postoperatively^[48-53]. The posterior translation was more than 5 mm in only six patients, but none of them had an over 10mm posterior displacement. The mean side-to-side difference was 2.7 mm, which is comparable with other series with long-term follow-ups. Hermans *et al*^[55] found a 4.7 mm mean difference in their patients. Similar results have been reported in other studies using autografts or allografts^[56]. The functional and clinical outcome was assessed through three knee-specific questionnaires: the IKDC Subjective Knee Form, the KOS-ADLS, the Lysholm scale, as well as a general health questionnaire, the SF-12 Health Survey^[43-45]. More than 70% of our patients scored good to excellent results in all measures used. Only one patient yielded disappointing results even though the objective assessment was normal. In our study the rate of post-traumatic arthritis was low (three out of 34 patients) compared to other studies with similar follow-up time^[3,57,58].

Very few studies underwent long-term follow-up^[2,3,57-61] and only two studies exceeded the ten-year follow-up limit^[3,59]. However most of these previous studies included both true dislocations and complex knee injuries together. Thus, making the sample heterogeneous, because the soft tissue injury is usually worse after a complete dislocation. In one of those, Engebretsen *et al*^[58] also included patients with different type of injuries, where they concluded that high-energy injuries had significantly lower functional scores. Furthermore in some of these studies with long term follow up the type of treatment was not consistent, either treating the patients in two stages^[57] or conservatively^[61]. Another issue, which was not

consistent in these studies, was the timing of operative treatment. In some of those the operation was performed in a later stage^[57], in others in an early stage^[58,59] and some of these studies included patients, who had treatment both in early and late stage^[58]. Recently, a study^[2] presented good results after long-term follow-up in patients with traumatic knee dislocations. However they included patients with vascular injury requiring repair, as well as some patients with high-energy injuries. In these cases, soft tissues very rarely heal in the first three weeks after the injury making impossible reconstruction in early stage, thus influencing negatively the final outcome. Treatment regime was not the same for all the patients since they used various grafts for ligament reconstruction, especially for the PCL. The incidence of posttraumatic arthritis also, was not reported. Faneli *et al*^[3], presented the study with the longest follow-up (over 10 years) and the patients had a standardized treatment protocol, utilizing allografts in a delayed fashion in the majority of the cases. They reported that the knee stability was restored but one fourth of the patients had developed post-traumatic arthritis. Interestingly, the same authors in a previously reported study^[62] with 10 years follow-up did not provide any information about post-traumatic arthritis. Engebretsen *et al*^[58] on the other hand reported high incidence of arthritis in his patients but they included all high-energy traumatic complete knee dislocations.

Our treatment regime included several standardized procedures. Firstly, the requirement for operating was to have a “quiet” knee with no blisters or edema, and with smooth range of knee motion. In all of our cases we achieved this goal using early CPM and active quadriceps exercises, at the limits of the pain. Therefore, we excluded the cases of knee dislocations requiring revascularization, as in these cases the repair had to be protected with knee immobilization, using an external fixator. This is the reason we used the term 'complex' knee injuries and not knee dislocations. In our experience, the latter is a different entity because of the severity of the soft tissue injury and the possible fasciotomies, associated with vascular reconstruction, which usually preclude early treatment of the knee

ligaments. Secondly, our aim was to operate in an early stage, trying to preserve the remnants of both, the ruptured PCL and the ruptured collateral ligaments. There is debate in the literature regarding the timing for treating complex knee injuries. Two systematic reviews, published both in 2009^[63,64] reported different conclusions regarding the timing of the operation. Levy *et al*^[63] suggested that early operative treatment of the multi-ligament injured knee yields improved functional and clinical outcomes compared to non-operative management or delayed surgery. On the other hand, Mook *et al*^[64] reported that delayed reconstructions of severe multiple-ligament knee injuries could potentially yield equivalent outcomes in terms of stability when compared with acute surgery. This is justified by the fact that acute surgery is highly associated with range-of-motion deficits. Hirschmann *et al*^[59] reported in 12 years follow-up (average) study with early reconstruction very good results regarding knee stability, but one fifth of the patients had extension deficits and one third of the patients had not satisfactory clinical outcome. The authors did not include patients with vascular repair but the ligament reconstruction was performed with open surgery. Recently Khakha *et al*^[2] reported a high level of overall knee function following acute surgical reconstruction with a 10-year average follow-up. However, the treatment protocol was not consistent, since they used different grafts for PCL and PLRI reconstruction. They also included patients requiring vascular repair, who needed postoperative immobilization; they however, have reported immediate knee motion postoperatively.

We have used also the artificial LARS ligament to reconstruct PCL. The artificial graft acts as a scaffold for the PCL remnants. The stable joint environment and the scaffold function of the LARS ligament promotes the healing procedure^[25,27,29,31,32,39,51]. Its use in ACL reconstruction as an isolated graft is contraindicated because it has failed in the majority of the cases even though it seemed successful in the short-term^[14-17,26,37,41,64]. The difference in PCL reconstruction is that the function of the graft in the acute phase is to acts as the

central support system, allowing the PCL remnants to heal in the correct position with minimal posterior laxity in the knee^[30,31,34,65]. Another advantage of the artificial graft is that there is no need for intensive postoperative rehabilitation using sophisticated devices. In all the cases we did not restrict the range of motion postoperatively. The surgical technique also is simpler than the conventional PCL reconstruction techniques, because the posterior portals are not needed, since the posterior exit of the tibial tunnel is assessed fluoroscopically, using the special guide of the LARS system. The risk of synovitis was reduced as we did not notice any case of synovitis in our sample and we are aware of only one case in the literature^[14,15]. Another benefit of this reconstructive procedure is that it permits fast return to daily activities and sooner to sports. In contrast to this fast return, hamstrings or other autografts require a period of graft revascularization, where activities are limited and rehabilitation program is extended. In addition, allografts always pose the risk of disease transmission^[18,20,21]. The advantage of preserving the PCL remnants was stressed out in two studies. Both Ahn *et al*^[32] and Zhao *et al*^[66] reported a preserving reconstruction method for chronic, however PCL injuries. The only study available to describe the results of remnant-preserving PCL reconstruction in the acute and sub-acute stage was presented by Jung *et al*^[31] but the authors have included patients in the sub-acute phase (3 mo post-injury). They also used hamstrings grafts, which require protection in the early postoperative period. Recently various reports have published good results after PCL reconstruction using LARS artificial ligaments^[19,37]. However only in one study the operation was performed in an early stage^[19] and the follow-up was relatively short (less than 5 years), which is considered a limitation when artificial grafts are used, because of their tendency to fail in a later phase^[15,16].

Despite our efforts, there are limitations in our study. It is a retrospective study, but the majority of similar studies are also retrospective, since the incidence of these injuries is very rare. A second limitation is the sample size, which seems rather small, however it is considered a homogenous sample, since we used a

standardized protocol regarding the timing of surgery and the treatment method. We have also excluded patients with vascular injuries, which require different treatment protocol and they also have different prognosis. The follow-up was long enough, compared to other similar studies, reported in the literature. Therefore, we believe that our proposed treatment protocol to treat complex knee injuries, operating in an early fashion and reconstructing PCL with LARS artificial ligament may restore knee stability and provide satisfactory long term clinical outcome.

ARTICLE HIGHLIGHTS

Research background

Complex knee injuries pose a difficult problem across the literature in terms of diagnostic classification while the treatment remains controversial. In particular, there is conflict regarding: (1) Their classification (as benign knee dislocations with intact neurovascular status and knee dislocations with arterial injury are not well classified); (2) their postoperative rehabilitation (as knee dislocations with arterial injury require a period of knee immobilization, whereas “benign” knee dislocations can be treated with aggressive postoperative rehabilitation); (3) the timing of the operation; (4) the graft type; and (5) the lack of long term follow-up. In our study we have tried to address all these issues, because we present a homogenous sample, with a long-term follow-up, using LARS artificial ligament to reconstruct PCL and all patients had the operations in the acute phase. Therefore, we feel that the results presented here are reliable since our study, although retrospective has a clear and robust methodology.

Research motivation

In medicine and in any other research processes, the researcher first he observes a phenomenon, secondly he tries to explain it with a theory, and lastly, he has to reproduce it, to confirm the theory. Taking this into account, we have observed that early reconstruction of these injuries provide better outcomes, because the

injured soft tissues, have a better healing potential in the acute phase. There is also always a fear for knee arthrofibrosis, when operating early these injuries; we have therefore, allowed (in all our cases) the inflammation to settle down with the help of intensive physiotherapy after the injury. The artificial ligament also provides the scaffold, necessary for the tissue healing in the appropriate position. Furthermore, it allows early rehabilitation because primary stability is achieved during the operation and no need for further protection is needed during the early postoperative period. The satisfactory outcome after this study's long-term follow-up is supporting the theory of early intervention following our treatment protocol.

Research objectives

The main objective of our study was to present a standard treatment protocol to manage complex knee injuries, taking into account parameters which have not been clearly elaborated in previous studies, such as postoperative rehabilitation, timing of the operation, follow-up etc. The various parameters of the protocol have been well defined and we suggest this protocol, since we have found very promising outcomes for our patient sample.

Research methods

In this retrospective study, we have used a range of clinical outcome measures and radiological parameters. Clinical measures included three knee-specific measures; the Knee Outcome Survey for Activities of Daily Living (KOS-ADLS), the Lysholm scale, the Knee Osteoarthritis Outcome Survey (KOOS) as well as a generic health measure, the SF-12 Health Survey, all of which present as the most commonly used self-reported outcomes in similar type of studies. In addition, for detecting any anteroposterior (AP) instability we have used the Telos devise. We have also used plain radiographs to detect any possible remaining instability and post-traumatic arthritis. However, we believe that the main advantages of our methodology is (1) our homogenous sample selection (not including patients with vascular injury or

major fracture around the knee); (2) the fact that the sample were all treated with the same standardized protocol; and (3) that postoperative rehabilitation was also intensive with no serious precautions regarding sophisticated and expensive braces.

Research results

Authors study we have found satisfactory clinical outcomes after a long period of time. The functional scores, which have been used in our study yielded very good results. The remaining instability was minimal in most cases and the rate of posttraumatic arthritis was not detectable in most of our cases, given the long follow-up. In future, we may have to include an MRI to detect any occult meniscal or cartilage injuries.

Research conclusions

The new findings of this study support the theory of early intervention following complex knee injuries (without concomitant serious vascular or bony injuries) as clinical, functional and radiological outcomes have all been satisfactory during our long follow-up. We propose to treat early these injuries, providing that the patient has achieved a good range of motion preoperatively. We also suggest augmenting PCL remnants with LARS artificial ligament, which has been proven adequate in the long-term follow-up. In summary, the proposed treatment protocol is efficient in complex knee injuries, providing there is no concomitant serious vascular or bony injuries. The new hypothesis proposed by this study is the reconstruction of complex knee injuries in the acute phase. The cornerstone of our approach is to start early intensive physiotherapy, to operate as soon as the inflammation settles down and to repair all tissues in one stage. We augment the PCL with LARS artificial ligament and we also augment the repair of collateral ligaments. Based on these findings, we feel that all these injuries should be treated in the acute phase. The new methods are the use of LARS artificial ligament, only for PCL

reconstruction and the repair of all the injuries in one stage. With this approach the patients may return earlier to their previous functional level. We feel that this is a major achievement because these injuries may be disabling when they are not treated appropriately.

Research perspectives

The experience learnt from this study was to proceed for proper classification of complex knee injuries. We cannot classify them all in the same category since the prognosis and the treatment protocol is different in injuries complicated with vascular or serious bony injuries. The direction of the future research should be oriented towards the better classification of these injuries and to determine the use of the various available grafts. The methods for future research, is either biomechanical or clinical. The problem with clinical studies, is the rarity of the injury, therefore multicenter studies are required.

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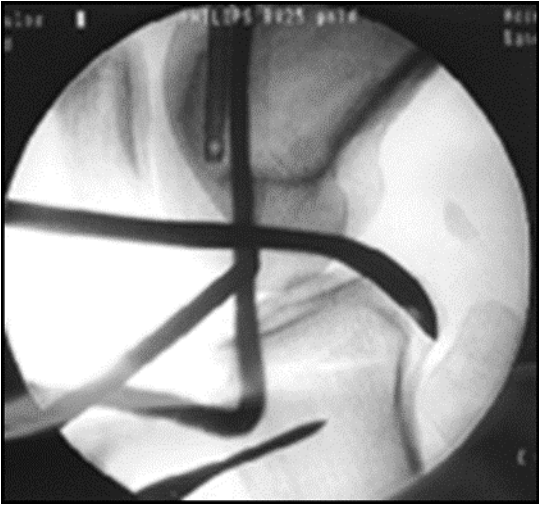


Figure 1 Tibial tunnel opening under image intensifier.

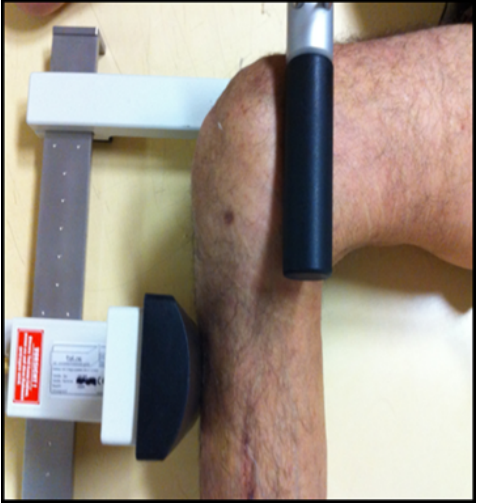


Figure 2 Proper position of tibia and femur for Telos Stress Device.



Figure 3 Anteroposterior force on tibia through Telos Device leading to posterior translation.

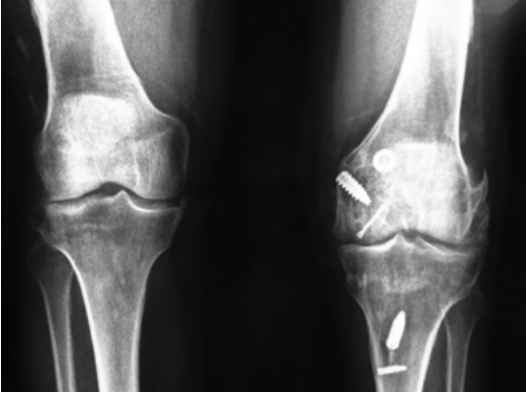


Figure 4 Anteroposterior knee x-rays for evaluation of arthritis progression (Kellgren and Lawrence grade 3).

Table 1 Patients data

Patient	Gender	Age	Cause and time of Injury	Injury	Operati on time after injury (wk)	Follow -up (yr)
1	Male	35	MVA (2007)	(R) PCL/MCL/MM	2	8
2	Male	46	MVA (2007)	(R)PCL/ACL/MCL part	4	8
3	Male	52	MVA (2003)	(L) PCL/ACL/LM	1	12
4	Male	19	MVA (2004)	(R) PCL/PLC/LM	4	11
5	Male	41	MVA (1997)	(L) PCL/ACL/LM	2	18
6	Male	36	MVA (2003)	(L) PCL/ACL	1	12
7	Male	25	MVA (2007)	(R) PCL/ACL/PLC	4	8
8	Male	20	MVA (2001)	(L) PCL/MCL/MM	4	14
9	Male	61	FALL (2006)	(R) PCL/ACL/MCL	1	9
10	Male	60	FALL (2007)	(R) PCL/ACL/PLC	3	8
11	Fem.	54	FALL (2000)	(R) PCL/ACL/	3	15
12	Male	37	MVA (2002)	(R) PCL/ACL	3	13
13	Male	25	MVA (2004)	(R)PCL/PLC/ACL/L M	1	11
14	Male	51	MVA (2007)	(L) PCL/MCL	4	8
15	Female	17	FALL (1999)	(L)PCL/ACL/LM	1	16
16	Female	28	FALL (2005)	(R)PCL/ACL/MCL part	1	10
17	Male	20	MVA (2000)	(L) PCL/MCL	4	15
18	Male	23	MVA (2003)	(R) PCL/PLC/LM	2	12
19	Male	38	MVA (2004)	(L) PCL/MCL	3	11

20	Male	37	MVA (2007)	(R) PCL/PLC	2	8
21	Male	27	FALL (2009)	(L) PCL/ACL	4	6
22	Female	36	MVA (2009)	(R) PCL/ACL/PLC	4	6
23	Male	33	MVA (2009)	(R) PCL/ACL/MCL/M M	4	6
24	Male	30	MVA (2010)	(L) PCL/ACL	1	5
25	Male	27	MVA (2010)	(L) PCL/ACL/PLC	3	5
26	Male	21	MVA (2010)	(R) PCL/ACL/MCL	2	5
27	Male	22	MVA (2011)	(R) PCL/ACL	1	6
28	Male	35	FALL (2010)	(R) PCL/ACL	4	5
29	Male	26	MVA (2010)	(R) PCL/ACL/MCL	2	5
30	Male	26	MVA (2010)	(R) PCL/ACL/MCL	4	5
31	Male	21	MVA (2011)	(R) PCL/ACL	4	7
Average		33.2 ±			2.67 ±	9.2 ±
e ± SD		12.5			1.24	4.27

Table 2 Functional scores

Patient Code	KOS-ADSL/70 100%	IKDC/87 x 100	Lysholm/100	SF-12	Physical subscale (%)	Mental subscale (%)
1	94.2%	88.5	91	51.1	62.4	
2	98.5%	79.3	100	54.8	59.8	
3	88.5%	83.9	85	49.3	61.4	
4	95.7%	98.8	91	56.6	60.8	
5	92.8%	77.0	88	56.6	60.8	
6	74.2%	65.5	83	48.7	61.5	
7	98.5%	98.8	100	56.6	60.8	
8	100%	94.2	100	57.2	33.8	
9	88.5%	62.0	94	48.0	62.5	
10	100%	98.5	100	56.6	60.8	
11	77.1%	72.0	88	56.6	60.8	
12	78.5%	80.4	90	53.1	59.9	
13	88.5%	83.9	69	53.0	57.0	
14	41.4%	24.1	48	30.8	40.5	
15	90.0%	93.1	85	56.6	60.8	
16	100%	95.4	100	56.6	60.8	
17	80.0%	52.8	90	38.8	61.5	
18	75.7%	60.9	58	47.6	48.6	
19	85.7%	81.6	95	54.1	53.8	
20	97.1%	95.4	99	56.6	60.8	

21	90.0%	81.6	99	55.3	60.7
22	97.1%	95.4	99	55.3	60.7
23	58.5%	49.4	67	42.8	57.0
24	92.8%	81.6	94	55.3	60.7
25	98.5%	100	100	56.6	60.8
26	92.8%	86.2	85	53.2	49.8
27	95.7%	90.8	94	56.6	60.8
28	77.1%	55.1	81	36.0	60.4
29	98.5%	89.6	94	56.6	60.8
30	92.8%	85.0	94	56.6	60.8
31	92.8%	81.6	86	55.3	60.7
Average	88.1 ± 12.47	79.32 ± 17.1	88 ± 12.4		
	± SD				

Table 3 Radiological results with Telos device

Patient code	Telos posterior displacement (mm) X-ray measured	
	Operated knee	Healthy knee (contralateral)
1	8	0
2	6	3
3	5	2
4	1	0
5	4	0
6	2	5
7	0	0
8	0	2
9	6	0
10	3	1
11	2	1
12	4	0
13	6	1
14	7	2
15	5	0
16	3	3
17	3	0
18	3	0
19	4	1
20	3	1
21	4	0
22	2	1
23	8	0

24	4	1
25	0	2
26	5	0
27	1	1
28	3	0
29	0	0
30	3	0
31	4	0
Average	3.61 (\pm 2.15)	0.91 (\pm 1.17)
(SD)		
