DOI: http://dx.doi.org/10.1590/1413-785220223002e246988

THE OUTCOMES OF POSTERIOR CRUCIATE LIGAMENT TIBIAL AVULSION FIXATION WITH A SCREW USING A DUAL POSTEROMEDIAL PORTAL TECHNIQUE

DESFECHOS DA TÉCNICA DE PORTAL PÓSTERO-MEDIAL DUPLO PARA FIXAÇÕES DE FRATURA EM AVULSÃO TIBIAL DO LIGAMENTO CRUZADO POSTERIOR

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ABSTRACT

Objectives: Our purpose was to evaluate the clinical results of PCL tibial avulsion fracture fixation performed with 4 mm cancellous screws using a dual posteromedial (PM) portal technique. Methods: In a prospective study, we followed 12 patients submitted to PCL tibial insertion avulsion arthroscopic fixation using dual PM portals with cancellous screws from March 2014 to Jan 2020. The proximal higher PM portal served as an instrument portal and provided an optimal trajectory for arthroscopic screw fixation of larger PCL avulsion fractures. The lower PM portal was used as a viewing portal. Results: Significant improvements were found between the preoperative and postoperative mean Lysholm scores at six months. The preoperative IKDC score mean of 10.13 increased to 89.3 at the end of six months. Minor adverse results with this technique were: grade I on posterior sag in five knees (41.6%), temporary stiffness in two cases (16.7 %), delayed union in one patient (8.3 %), and difficulty squatting at the end of six months in one patient (8.3%). Temporary extension lag was present in two individuals (16.7%), and fixed subtle flexion deficit of 3-5 degrees occurred in one individual (8.3 %). Conclusion: The outcomes obtained with the proposed technique were similar to those obtained with open techniques, although mild flexion deficits and discreet posterior sag may be present in a significant number of cases. ***Level of Evidence II; Prospective Cohort Study.***

Keywords: Posterior Cruciate Ligament. Fractures, Avulsion. Surgical Procedures, Arthroscopic.

RESUMO

Objetivos: O objetivo foi avaliar os resultados clínicos da fixação da fratura da avulsão tibial PCL realizada com parafusos esponjosos de 4 mm, utilizando uma técnica de portal postero-medial (PM) duplo. Métodos: Em um estudo prospectivo, acompanhamos 12 pacientes submetidos à fixação da avulsão tibial de inserção PCL por via artroscópica utilizando portais duplos PM com parafusos esponjosos de março de 2014 a janeiro de 2020. O portal PM proximal superior serviu como um portal de instrumentos e forneceu uma trajetória ideal para a fixação artroscópica com parafusos de fixação de fraturas avulsas PCL maiores. O portal PM inferior foi usado como um portal de visualização. Resultados: Foram encontradas melhorias significativas entre o pré-operatório e o pós-operatório, com pontuação média de Lysholm aos seis meses. A pontuação média do IKDC pré-operatório de 10,13 aumentou para 89,3 no final dos seis meses. Os resultados adversos menores com esta técnica foram: grau I na flacidez posterior de cinco joelhos (41,6%), rigidez temporária em dois casos (16,7%), união tardia em um paciente (8,3%) e dificuldade de agachamento ao final de seis meses em um paciente (8,3%). O atraso temporário da extensão estava presente em dois indivíduos (16,7%) e o déficit de flexão sutil fixo de 3-5 graus ocorreu em um indivíduo (8,3%). Conclusão: Os resultados obtidos com a técnica proposta foram similares aos obtidos com técnicas abertas, embora déficits leves de flexão e discreta flacidez posterior possam estar presentes em um número significativo de casos. ***Nível de Evidência II; Estudo de Coorte Prospectivo.***

Descritores: *Ligamento cruzado posterior. Fratura Avulsão. Procedimentos Cirúrgicos Artroscópicos.*

Citation: Vishwakarma NS, Gali JC, Gali Filho JC, LaPrade RF. The outcomes of posterior cruciate ligament tibial avulsion fixation with a screw using a dual posteromedial portal technique. Acta Ortop Bras. [online]. 2022;30(2)Esp.: Page 1 of 6. Available from URL: http://www.scielo.br/aob.

All authors declare no potential conflict of interest related to this article.

The study was conducted at the multiple institutes where the primary surgeon is associated.
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Article received on 12/25/2020, approved in 03/16/2021.

INTRODUCTION

Isolated posterior cruciate ligament (PCL) tibial avulsion fractures account for 20 % of the total knee ligament injuries.[1] The PCL is the central pivot of the knee and predominantly resists the posterior translation of the tibia in all knee positions.[2] The mode of injury in PCL is commonly classified as dashboard, hyperextension, fall on the flexed knee with the foot in plantar flexion, and hyperflexion injuries.[3] Trivial domestic PCL injuries form a less sizeable group. Contact, athletic sports and road traffic high energy injuries form the majority of cases.[4]

Multiple biomechanical studies have shown that PCL deficiency if untreated may lead to increased risk of meniscal tears, medial compartment, and patellofemoral osteoarthritis.[4,5] PCL avulsion fracture fixation was advocated by Griffith et al. to avoid the above complications including nonunion and late degenerative osteoarthritis.[6] Dhillon et al. have suggested that poor outcome is common if the PCL avulsion fractures are treated beyond 16 weeks of its occurrence.[7] Ohishi et al. recommend surgical reinsertion and fixation of displaced PCL avulsion fractures.[8]

Posterior compartment arthroscopy is essential during PCL reconstruction, PCL avulsion fracture fixation, subtotal synovectomies, posterior loose bodies removal, longitudinal tears involving the peripheral attachment of the medial meniscus' posterior horn (ramp lesions) repairs and even meniscal transplants. [9,10]

The transseptal portal is used by some surgeons during PCL related surgeries.[8,11] The addition of this portal increases the visualization and aids in the direct passage of instruments for reduction. But the transseptal portal is specifically risky during PCL avulsion fracture fixations. The most dangerous risk is injury to the popliteal vessels.[11,12] The neurovascular bundle is at risk not only during transseptal portal creation during PCL surgery steps, but also during negligent posterolateral (PL) portals. The PL compartment is smaller than posteromedial (PM) compartment by more than 1.5 times.[8] The popliteal artery has been found closer to posterior septum and may be a deterrent for creating transseptal portal from medial to lateral side. Kim et al. suggested that the transseptal has to be made from lateral to medial side to obviate any small chance of popliteal neurovascular injury. The PL portal needs to be created from outside-in technique therefore and it may be difficult to enter the smaller PL compartment.[13]

The PCL can be viewed entirety via PM portal. The previous literature suggests use of a single PM portal or the addition of a transseptal portal during PCL surgeries.[11,13,14] We propose use of dual PM portals to prevent the additional risk when creating transseptal and PL portals. The high PM portal serves as instruments working portal and the other PM portal as a viewing portal. The cadaveric study done by Pace and Wahl [12] suggested a safe zone in relation to the saphenous vein. They suggested knee flexion to 90 degrees as a mandatory position during the PM portal creation.[15] The injury to the saphenous nerve and vein was documented by multiple studies but the occurrence is uncommon.[15,16]

PCL avulsion fracture may be fixed with 4 mm cancellous using two PM portals[15-17] placed in the safe zone with consideration of the capsular folds for PCL tibial avulsion fixation with screw. Fixation method of PCL avulsion fracture is usually dictated by the size of the fragment. The smaller fragments are fixed using suture techniques. The 4mm cancellous cannulated with washers are utilized for larger fragments.[18,19] Posterior approach[20] and Burk Schaffer's approach including its modification[21] may be used for this purpose, too.

In the arthroscopic PCL tibial avulsion fixation transseptal or posterolateral portals may be used, and they may increase the risk to the knee posterior neurovascular anatomical structures. Zhao et al. fixed PCL tibial avulsion by two PM portals with polyester sutures fixed on a titanium tibial button,[22] Gui et al. also utilized two PM portals for avulsion fragment fixation with PDS sutures tied over a screw into the tibia[23] and Gwinner et al. used additional PM portals to perform PCL avulsion fracture using Tight Rope® device.[24]

This study aimed to evaluate the clinical outcomes of PCL tibial avulsion fracture fixation using dual PM portal technique, to avoid neurovascular anatomical structures injuries that may happen with PL portal, and done with screws, in order to provide a more rigid fixation.

MATERIALS AND METHODS

Ethical committee approval was taken prior to the study protocol introduction. In a prospective study, we followed 12 patients submitted to PCL tibial insertion avulsion arthroscopic fixation from March 2014 to Jan 2020. The inclusion criteria were isolated PCL avulsion fractures evaluated by clinical evaluation and confirmed with CT or MRI, and closed physes. Exclusion criteria were tibial avulsion fragment less than 1 cm, pre-existing knee arthrosis, any ligaments insufficiency which may need additional procedures, multiligamentous knee dislocations, any extension of fracture on the tibial plateau either medially or laterally, any avulsion fracture beyond 12 weeks, polytrauma patients with medical comorbidities and history of knee surgery in past.

All 12 patients were meticulously followed for a minimum of six months post-surgery. None of patients were lost to follow-up. Acute patients were considered those whose treatment was performed within three weeks of fracture occurrence, those whose treatment was performed between three and six weeks were classified as subacute and those treated between six and 12 weeks were considered chronic.

There were nine (75%) men and three (25%) women. Their mean age was 39.9 years (range from 29 to 50). There were five patients (41.7%) with road traffic injuries, four patients (33.3%) with hyperflexion knee injury mechanism, two patients (16.6%) caused by hyperextension and in one patient the mechanism was unknown. Seventy-five % (nine cases) were acute, one (8.3%) subacute and two (16.6%) were chronic.

The history was followed by a complete clinical examination to evaluate the posterior sag secondary to PCL tibial avulsion fracture. The mechanism of injury was documented as well. The knee was specifically evaluated of any additional ligament injury or neurovascular involvement. The MRI in addition to the basic X-ray enables the fixation method to be chosen and also aids in excluding the extension in the tibial plateau which can be missed on plain X-rays. When the fragment size was critical to the screw used for fixation we analyzed the CT scans, too. We fixed tibial avulsion fragments equal or greater to 1 cm to prevent splintering of the fragment while screw insertion. The patient was explained about the procedure along with the rehabilitation protocol and standard consent is taken. The follow-up X-ray was done at six and 12 weeks as per study protocol.

Surgical Technique and Rehabilitation

All 12 patients were operated under spinal anesthesia and tourniquet control. Leg hanging position was utilized with legs hanging within a thigh holder and unhindered flexion was checked. The thighs were abducted to increase the space between the two thighs to increase the working space which has to accommodate the arthroscope as well as multiple instruments including drill bits for screws passage. The anteromedial and anterolateral arthroscopic portals were created close to the patellar tendon and just a little above the joint line as the maximum work in through the intercondylar notch.

The meniscal pathologies were tackled initially. The arthroscope was then pushed in the PM compartment and the two portals were created by outside-in technique under direct visualization in the safe zone based on synovial folds of medial head of gastrocnemius and semimembranosus as described by McGinnis et al.[17] The needles

and instruments were always directed from posterior to anterior angulation to avoid any neurovascular injury. The low portal was termed the viewing portal and the high PM portal was considered the instrument or working portal. Two arthroscopic cannulas were used to facilitate the introduction of arthroscope and instruments. (Figure 1) The arthroscope was placed in the lower PM portal. The higher PM was created to get adequate optimal trajectory for the suture instruments and drills to pass in the PCL facet on the tibia. The fragment was secured by guide wire followed by sequential drilling and 4mm cancellous cannulated screw insertion over washer. (Figure 2) There were certain tricks with the reduction. Many times a small serrated punch was used to push the PCL avulsion fracture towards the PCL facet. Alternatively, we had used a cannulated drill bit with serrations to reduce the fragment directly and then passed the guide wire from within to secure the fragment. Also, in one case, we used a PCL zig to firmly pull the fragment back as the wire was passed. Another way of reducing fragment was passing a suture from a scorpion biter and then passing a temporary suture through the substance of PCL and then push that suture along with the fragment towards the PCL facet with a knot pusher. Many times just passing the guide wire or drill rotated the fragment to a certain extent but then passing two wires settled that issue.

The screw trajectory had an angle that is directed from posteromedially to anterolaterally. The patients were given compressive crepe bandage dressing with knee immobilizer postoperatively. Pre and postoperative X-rays are showed at Figure 3.

Physiotherapy and bedside mobilization was advised immediately. Restricted or protected weight bearing was permitted after three weeks although range of motion was advised from day one. The patients were allowed to graduate from partial weight bearing starting from three weeks to full weight bearing by six weeks. The physiotherapy focused on regaining quadriceps strength and complete knee extension. The patients returned to their activities of daily living after three months. Bike, cycle was utilized during the postoperative phase after six weeks. Running, deep squatting was allowed only after complete range of motion and radiological union confirmation after three months.

The follow-up was done at two weeks, for portal stitch removal. The patients were asked to do an X-ray at six weeks and three months. Clinical evaluation of results was done using Lysholm and International Knee Documentation Committee (IKDC) score at three and six months' post-surgery.

Statistical Analysis

The Lysholm and International Knee Documentation Committee (IKDC) scores were evaluated statistically using SPSS (statistical package for social sciences) 25 version. The parametric paired Student's t-test was utilized for statistical calculations. The significance (α) was fixed at p=0.05.

RESULTS

All X-rays showed fracture union by six weeks except one case (8.3%) which showed delayed union but consolidated at 16 weeks. There were no complications directly related to the surgical procedure itself, such as failure of fixation, thrombophlebitis, neurovascular injuries, superficial or deep infections.

The following minor adverse results occurred in our cohort study: grade I on posterior sag was present in five knees (41.6%) as compared to contralateral side, although none had objective symptoms due to patellofemoral issues; temporary stiffness in two cases (16.7 %); temporary extension lag in two individuals (16.7%) delayed union in one patient (8.3 %); one patient (8.3%) had difficulty squatting at the end of six months; and fixed subtle flexion deficit of 3-5 degrees in one individual (8.3 %) occurred in a chronic case operated beyond six weeks post-injury and minor swelling persisting for three weeks post-surgery. (Table 1)

The follow-up at three months showed quadriceps wasting objectively with difference in thigh girth, difficulty to squat and fixed subtle flexion deficit of 3-5 degree in one (8.3 %) chronic case. The patient

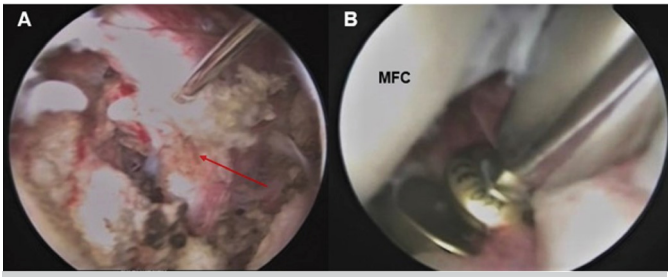

Figure 2. Arthroscopic view of the posterior left knee showing the fractured fragment reduced with a guide wire (red arrow) (A), the fragment fixation with one screw and the medial femoral condyle (MFC) (B).

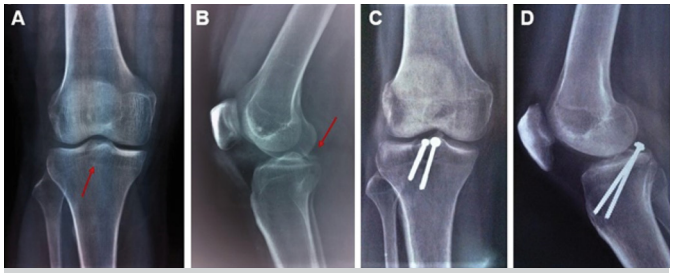

Figure 3. Preoperative AP X-ray of a right knee showing the fracture line (red arrow) (A), preoperative lateral X-ray showing the avulsioned fragment line (red arrow) (B), the reduction and fixation of the fractured fragment at the AP X-ray (C) and lateral X-ray (D).

Figure 1. Arthroscopic view of the posteromedial left knee corner showing one needle (red arrow) introduced from posterior to anterior and the medial femoral condyle (MFC) (A) the higher portal with one cannula (B) and two cannulas inside higher and lower portals (C).

was aggressively subjected to physiotherapy and at six months' quadriceps wasting recovered but difficulty in squatting persisted. Despite that adverse results the preoperative Lysholm score mean was 28.2 which increased to 75.4 at six months. Student's t-test yielded a P=0.000 which proves that the difference was statistically significant. The preoperative IKDC score mean of 10.1 increased to 89.3 at the end of six months and was statistically significance (p=0.000). (Table 1)

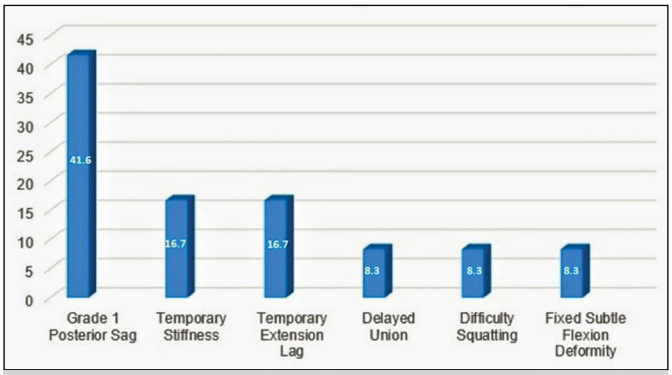

Figure 4. Adverse results after surgical treatment, in percentage.

Table 1. Comparative scores before and after the surgical procedure.

	Preoperatively	Postoperatively	p value
Mean Lysholm Score	28.2	75.4	0.000
Mean IKDC Score	10.1	89.3	0.000

DISCUSSION

The most important finding of our study was that transseptal and PL portals may be unnecessary for PCL tibial avulsion fixation if one more proximal PM portal is added for arthroscopic passage of the cancellous screw since it provides an optimal screw trajectory and this technique's outcomes were similar to those obtained with an open one.

In our study 75% of the patients were males and maximum patients were falling in the age group between 29-50 years with mean age being 39.9 years. Road traffic accident type (41.7%) was the main cause to produce upper pretibial contusion and PCL avulsion fractures in our population as we had an age group of people who got involved in vehicular type incidents with dashboard as the predominant mechanism. Data from literature are varied: in most articles, there is a predominance of males, ranging from 66.6 to 90 %,[6,18,22-27] patient's mean age diversified from 30 to 42.9 years,[6,18,22,23,24,26,27] and predominant mode of injury of PCL avulsion fractures was traffic accidents (57-90%).[18,22,23,26,27] According to Pache et al. dashboard trauma is the more common vehicular accidents whereas non-contact mechanism like hyperflexion and hyperextension are less common.[28]

All of our patients with PCL tibial avulsion were treated with arthroscopic fixation of the fragment by screws using two PM portals, but some authors did it through an open posterior approach.[18,26,29] Griffith et al. attached their PCL avulsion fractures either by arthroscopy or open surgery,[6] Chen et al. did arthroscopic suture fixation of the fragment using PM and PL portals[27] and Gwinner et al. created PM portals as needed in order to improve visualization of the PCL avulsion fracture and used Tight Rope® suture to fix the fragment.[24] Zhao et al. utilized two PM portals to fix PCL tibial avulsion with polyester sutures secured on a tibial button,[22] and Gui et al. created two PM portals for arthroscopic fixation of the PCL avulsed fragment tied over a screw in the tibia with PDS sutures.[23] Theoretically fracture fragment could have a more rigid fixation with screws.

The screw trajectory for PCL avulsion fixation was directed from posteromedially to anterolaterally and it is governed by the high instrument PM portal. It is not perpendicular to the fracture plane and their placement cannot be bicortical, as further advancement of the screw may injure the peroneal nerve if the angle of screw placement is extremely oblique and it ventures near the tibia-fibular side, also. Such an angle is only possible if the PM instrument portal is very low and anterior.

It was not possible to define a normal angle interval for the screw trajectory since we had a small number of patients. This angle which may injure the common peroneal nerve can only be validated by cadaveric studies. And to our knowledge, there are no papers in literature with arthroscopic screw fixations for PCL avulsion fractures as reference, and consequently there are no issues with concerning to the union in spite of screw obliquity, too.

All fracture healing occurred by six weeks except one chronic case (8.3%) which showed delayed union but had united at 12 weeks. This was the reason why it was unnecessary to repeat X-Rays after this period of time. One factor that had led to good union at six weeks in 11 cases might be that we have chosen avulsion fractures which had a size of 1 cm or greater wherein screw could be inserted without further splintering the fragment, and compression with screw with or without washer was achieved as well. Data from literature reports complete osseous healing of the bony avulsion in all cases[23,24,26,27,30] but Abdallah et al. reported one failure of fixation in a on-compliant patient.[25]

Regarding posterior instability, asymptomatic grade I posterior sag persisted in five knees (41.6%) of our population, possibly due to intrasubstance elongation[18,19], although none had any objective symptoms due to patellofemoral issues in our the short term follow-up.

Some authors reported the results of the PCL avulsed fragment arthroscopic fixation. For Chen et al. in 94.4% of patients the anterior-posterior translation was 0 to 2 mm and in 3 to 5 mm, in 5.6% of them.[27] Gwinner et al. patients had 2.8mm mean posterior tibial translation.[24] For Zhao et al. one of their 29 patients had 1+ positive posterior drawer test and it was negative in other patients.[22] Finally for Gui et al. the side-to-side difference was 0 to 2 mm in 23 patients and 3 mm in one patient.[23]

Other authors reported the results of open fixation of the PCL avulsion. Nicandri et al. reported that 80% of their patients had grade I laxity, and 20% demonstrated laxity grade II.[26] For Abdallah et al. the posterior drawer test returned to normal in 22 patients (81.5%), and it was grade I and II in 14.8% and 3.7% of the patients, respectively.[23] Piedade et al. reported that there was a residual draw of + (0.5 cm) to ++ (1 cm) in 95% of the cases. These authors believe that clinical outcomes suggest that PCL avulsion fracture should be interpreted as a bone-ligament injury,[16] although Inoue et al. didn't find any significant differences between normal and occult PCL mid-substance injury outcomes in primary repair of its avulsion fracture.[19]

Relating to motion deficit we had temporary stiffness in two cases (16.7%) and fixed subtle flexion deficit of 3-5 degrees in one chronic case (8.3 %) operated beyond six weeks.The PCL avulsed fragment arthroscopic fixation results were reported by some authors. In Zhao et al. series there was no extension limitation and flexion limitation in 6.8 % of the patients.[22] Gui et al. reported normal range of motion in 83.3% of the knees and terminal flexion limitations in 16.6 of them.[23] Chen et al. published that 27.7% of their patients had an extension deficit exceeding 10° and 8.3% of them showed flexion deficits between 16° and 25°.[27] On the other hand, Nicandri et al. using an open access for PCL avulsion fixation published that any of their 10 patients showed flexion difference greater than 10 degrees and extension difference greater than two degrees. In addition to the review of medical records of six patients lost to follow-up demonstrated that all had regained a functional range of motion, characterized as loss of extension <5 and flexion > 115°.[26]

Regarding subjective evaluation, our mean Lysholm and IKDC scores at the end of six months were 75.4 and 89.3, respectively. Some authors also reported the results of subjective evaluation of arthroscopically treated patients. In Zhao et al. series the postoperative Lysholm score was 97.4 and the IKDC score was 97.1.[22] Chen et al. in his series of 36 patients the mean postoperative Lysholm score was 95,[27] and Gwinner et al. reported a mean Lysholm score of 82 and a mean IKDC was 72.6[24]. One publication whose authors used open approach fixation reported good and excellent postoperative Lysholm score in 43% and 57% of cases, respectively[16] and another paper, where the authors also used open access reported an average Lysholm score of 91.[29] Table 2 shows a comparative description of general outcomes. It's possible to realize that it may be difficult to compare the results of the residual posterior instabilities among the authors because they used different ways to describe them. On the other hand we noticed that flexion deficits are more common among the outcomes of authors who used arthroscopic treatment of PCL avulsion although these deficits have not been described by authors who used open surgery treatment or small deficits were considered normal.[26] Regarding the Lysholm and IKDA scores, they are subjective and may vary from one studied population to another.

Although a review of PCL avulsion fractures and the available treatment options,[31] two systematic studies[32,33] and one paper[30] reported similar outcomes for both open and arthroscopic PCL avulsion fractures fixation, the immediate postoperative recovery may be faster and less painful with arthroscopic approach.[24] Hooper et al. suggested that arthroscopic approach may gives a chance to treat intra-articular pathologies which can have a bearing in outcome when only open approaches were used, and that the arthroscopic procedure may have higher subjective and objective results scores, and slightly higher rate of arthrofibrosis.[33]

Our study has some limitations: the first one is the small number of cases, the absence of a control group and short follow-up, although we found some published papesr with fewer patients than in our study.[24,26,29]

Table 3. Summary Description of General Outcomes.

	Residual Posterior Instability	Motion Deficit	Lysholm Score	IKDC Score
Zhao et al. AS - 2006	3.4% PDT 1+	6.8% FD	97.4	97.1
Gui et al. AS - 2009	88.4% 0-2 mm PTT	16.6% FD	NA	NA
Chen et al. AS - 2012	94.4% 0-2mm PTT	27.7% ED >10º	95	NA
Gwinner et al. AS - 2016	2.8 mm mean PTT	NA	82	72.6
Piedade et al. OS - 2007	95% RD 1+ or 2+	NA	43% Good 57% Excellent	NA
Nicandri et al. OS - 2008	80% Grade I Laxity	Any Patient FD>10º, ED >2º	NA	NA
Chiarapattanakom et al. OS - 2009	NA	NA	91	NA
Abdallah et al. OS - 2017	14.8% Grade I 3.7% Grade II PDT	NA	NA	NA
Our Results AS	41.6% Grade I TPS	8.3% 3-5º FD	75.4	89.3

AS = Arthroscopic Surgery, OS = Open Surgery, PTT = Posterior Tibial Translation, PDT = Posterior Drawer Test, RD = Residual Draw, ED = Extension Deficit, FD = Flexion Deficit, TPS = Tibial Posterior Sag, NA = Not Available.

CONCLUSION

The PCL avulsion screw fixation by dual PM portal technique's outcomes was similar to those obtained with open approach. Nevertheless, mild flexion deficits and discreet posterior sag may be present in a significant number of cases, and this may lead to patellofemoral degenerative changes in the long term.

AUTHORS' CONTRIBUTION: Each author developed individually and significantly for this article. NSV: writing, performing surgeries and final approval of the manuscript version to be published; JCG: acquisition of data for the work and criticism of its intellectual; JCGF: substantial contribution in the creation of the manuscript and final version of the version to be published; RFL: analysis or interpretation of data and critical review of its intellectual content.

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