International Journal of Latest Research in Science and Technology **ISSN (Online):2278-5299**
Volume 4, Issue 4: Page No.31-35, July-August 2015
https://www.mnkpublication.com/journal/ijlrst/index.php

ANATOMICAL STUDY OF TIBIAL INSERTION OF POSTERIOR CRUCIATE LIGAMENT IN ELDERLY AGED CHINESE POPULATION

[1]Chandan Kumar Jayswal, [1]Md. Shahidur Khan, [1]Cong Chen, [1]Yuanjun Teng, [1]Meng Wu, [1]Yayi Xia
[1]Department of Orthopaedics, Orthopaedics Key Laboratory of Gansu Province, The Second Hospital of Lanzhou University, Lanzhou City, Gansu Province, 730030, China

Abstract- ***Objective: The aim of the current study was to record the various measurements of Posterior Cruciate Ligament (PCL) on tibial surface in both sexes and both legs in elderly aged Chinese patients who were scheduled for undergoing Total Knee Arthroplasty (TKA) and to evaluate the results statistically. Methods: 75 tibial cut-off bones of Chinese patients were collected during TKA intra-operatively. Among them, in male 10 samples were from left and 3 from right knee, and in female 34 samples from left and 28 from right knee, who varied in age from: 45 to 75 years old. Those samples were evaluated in order to make measurements from tibial insertion of PCL to anterior region of the tibial plateau, from tibial insertion of PCL to center of tibial plateau, from center of the tibial insertion of PCL to the medial region of the tibia and from center of the tibial insertion of PCL to the lateral region of the tibia. Results: The anteroposterior diameter of tibial plateau is 43 mm; tibial insertion of PCL is 34 mm from the medial cortex and 36 mm from lateral cortex of tibia. Conclusion: The PCL has extensive insertion on Tibial Plateau. Our study concludes that the tibial insertion of PCL is slightly medial on the tibial plateau in both left and right knees in both male and female. So the location of center of the tibial insertion of PCL has no significant differences in terms of gender and side distribution among elderly Chinese population.***

Key Words: Knee joint; anatomy; posterior cruciate ligament; total knee arthroplasty

I. INTRODUCTION

Knee joint is one of the complex synovial joint in the body comprising of patello-femoral joint and tibio-femoral joint [1]. The PCL originates from a broad, crescent-shaped area on the anterolateral aspect of the medial femoral condyle in the intracondylar notch over a broad insertion and inserts into a depression between the two tibial plateaus named the PCL fossa [2]. The tibial attachment of the PCL is into a depression between the 2 plateaus, approximately 1 cm distal to the articular surface of the tibia, and extends distally several millimeters onto the posterior surface of the tibia. Fibers attach to the tibia in a medial to lateral direction. The PCL attaches with several additional slips, including a slip to blend with the posterior horn of the lateral meniscus [3]. The PCL is located near the longitudinal axis of rotation and just medial to the center of the knee. It is directed vertically in the frontal plane and angles forward 30^{o} to 45^{o} in the sagittal plane, depending on the degree of knee flexion. It is more vertical in extension and more horizontal in flexion. The dimensions of the PCL have been outlined by Girgis et al. [4] and Harner et al. [5] It is 32 to 38 mm long with a cross-sectional area of 11 mm^2 [5]. The bony insertion sites of the PCL are 3 times larger than its midsubstance. The ligament is enclosed within synovium and is, therefore, extra-articular in an anatomic sense [6, 7]. The synovium is reflected from the posterior capsule, and covers the medial, lateral, and anterior aspects of the PCL. Distally, the posterior portion of the PCL blends with the posterior capsule and periosteum [7].

The PCL has been denoted as the primary stabilizer of the knee by some authors [8-11]. The PCL provides 90% to 95% of total restraint to posterior displacement of the tibia on the femur [12, 13]. With 30^{o} of flexion of the knee, there is a drop in the tension of both cruciates. As flexion continues, there is progressive increase in PCL tension. Maximal tension is arrived at full flexion [14]. No other structure contributed more than 2% to the total restraint. Therefore, abnormal posterior tibial translation cannot occur without injury to the PCL. The medial fibers from the tibia insert anteriorly on the femur [6]. Functionally, the PCL appears to be arranged in 2 inseparable bands, named for their insertion positions [4, 6]. The Anterolateral Band (ALB) is more robust, and arises from the convex portion of the femoral attachment. The AL band is lax in extension, and becomes taut as flexion increases past 30^{o} [4, 6, 15]. The Posteromedial Band (PMB) is thinner, runs a more oblique course, and attaches more distally on the tibia [4, 6]. The PM fibers are taut in extension and lax in flexion [6, 15]. This contributes to the "screwhome mechanism" of the knee as it goes from flexion to extension [14]. Scapinelli [16] has described the bold supply to the knee. The major vessels are the supreme genicular artery, the medial and lateral superior genicular arteries, the middle genicular artery, and the anterior and posterior tibial recurrent arteries. The vascular supply to the PCL is from the middle genicular artery, which arises from the popliteal artery behind the popliteal surface of the femur. It runs anteriorly and penetrates the posterior capsule of the knee joint in the intercondylar notch. The artery supplies blood to both cruciates, synovial membrane, posterior capsule, and the epiphyses of the tibia and femur. The synovial tissue around the PCL is also a major blood source for the ligament. The base of the PCL is supplied by capsular vessels arising from the popliteal and inferior genicular arteries [6, 17]. Kennedy et al. [18] identified two

Publication History
Manuscript Received : 10 August 2015
Manuscript Accepted : 20 August 2015
Revision Received : 25 August 2015
Manuscript Published : 31 August 2015

distinct groups of afferent nerves in the knee. There were a posterior group, including the posterior articular and obturator nerves, and an anterior group, including branches from the femoral, common peroneal and saphenous nerves. Four types of receptors are found in the PCL, namely Ruffini slow adapting M-receptors, Pacinian fast adapting M-receptors, Golgi-like tension receptors and pain receptors [18, 19].

The present study was aimed to demonstrate the various measurements of the distances from the centers of the tibial insertions of the bands of the PCL to the medial and lateral cortical bone of the tibia, so that these might guide the creation of anatomical tunnels during operation and so that these might serve as analytical parameters for positioning bone tunnels after these operations. Besides that, also for evaluating gender and sides differences through morphometric analysis in elderly aged group who were scheduled for undergoing TKA surgery. This study contributes to the morphometric data on PCL and it is different from other studies by evaluating the gender and side differences among elderly Chinese population.

II. MATERIALS AND METHODS

The study protocol was approved by The Second Hospital of Lanzhou University. After obtaining approval from our university's internal review board, 75 Chinese patients (13 male and 62 female) were selected, among them, in male 10 samples were from left knee and 3 from right knee, and in female 34 samples from left knee and 28 from right knee, who varied in age from: 45 to 75 years old (Chart 1). Donors with known prior knee injuries, surgery, and known communicable disease, such as hepatitis and acquired immunodeficiency syndrome, and who were known to be from high-risk groups, such as intravenous drug users, were excluded. They were scheduled for undergoing total knee arthroplasty surgery, using tibial bone (shin bone) proximal cut off part in the process of tibial arthrotomy, with the aim of studying the anatomy and making measurements of the position of posterior cruciate ligament on the tibial surface. The data were taken since March 2014 to March 2015, which was a retrospective study of data prospectively collected at the time of surgery. All patients signed informed consent before the study.

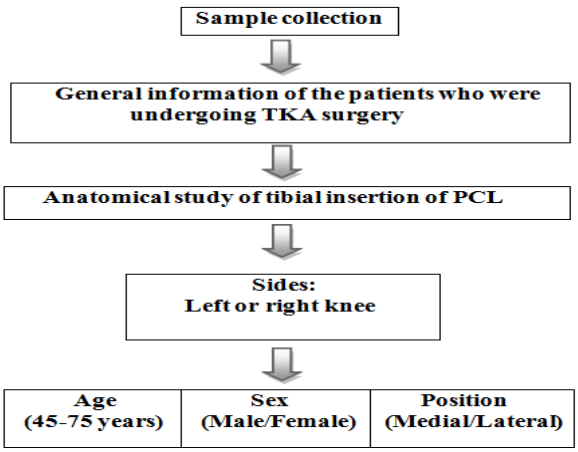

Chart 1: Overview Chart

Surgical Procedure

During the total knee arthroplasty surgery, the incision was given at the medial border of the quadriceps tendon 7 to 10 cm proximal to the patella, curve it around the medial border of the patella and back toward the midline, and end it at or distal to the tibial tuberosity. The incision was made about 8-10 inches long to expose knee joint. Deepen the dissection between the vastus medialis muscle and the medial border of the quadriceps tendon, and incise the capsule and synovium along this medial border and along medial border of the patella and patellar tendon. Once knee is open, the surgeon rotates the patella outside the knee area. This allows the surgeon to view the area needed to perform the surgical procedure. Then during the process of tibial arthrotomy, the proximal tibia (tibial shin bone) is cut perpendicular to the mechanical axis of the tibia using either intramedullary or extramedullary alignment rods. After that, the piece of bone cut-off from proximal tibia in which PCL band was attached (Fig. 1), was taken on a plane paper and its circumference was drawn outline by a lead pencil (Fig. 2). Then center of the Tibial insertion of PCL was marked with pencil (Fig. 2). To make measurements, an Aero Space metal pachymeter (150mm) was used (Fig. 3 & 4). The lengths of the distances between significant points were measured in millimeters. The following measurements were made:

a) From tibial insertion of PCL to anterior region of the tibial plateau i.e. Width of the Tibial Plateau (WTP)-AB (Fig. 5).

b) From tibial insertion of PCL to center of tibial plateau i.e. Mid-point of Tibial Plateau/half of WTP (MTP)-AC (Fig. 5).

c) From mid-point of tibial plateau/half of WTP to the medial region of the tibia i.e. Center of the tibial insertion of PCL to the medial region of the tibia (TIM)-CD (Fig. 5).

d) From mid-point of tibial plateau/half of WTP to the lateral region of the tibia i.e. Center of the tibial insertion of PCL to the lateral region of the tibia (TIL)-CE (Fig. 5).

Fig: 1 the piece of bone cut-off from proximal tibia during Arthrotomy process in TKA showing PCL bands

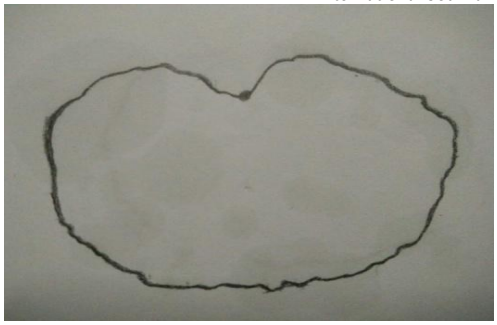

Fig: 2 Outline of bone piece in which center of the tibial insertion of PCL was marked

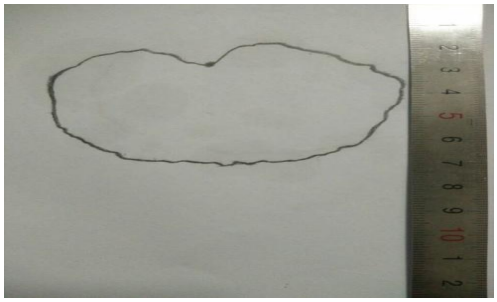

Fig: 3 Measurement of various distances using an Aero Space metal pachymeter (150mm)

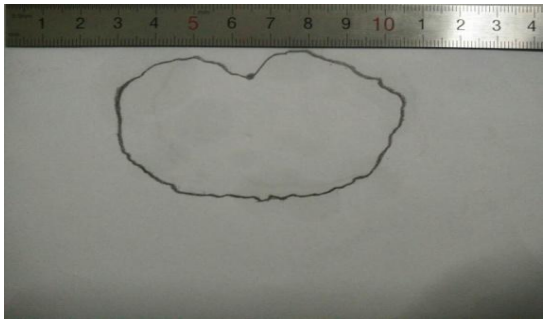

Fig: 4 Measurement of various distances using an Aero Space metal pachymeter (150mm)

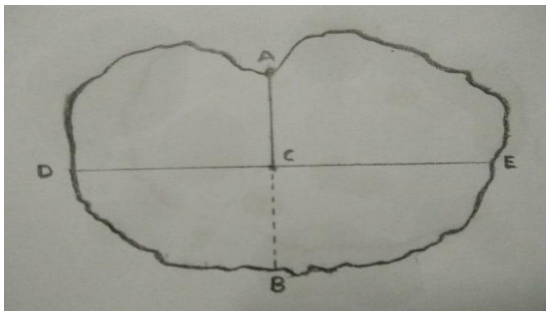

Fig: 5 Measurement of various distances;

AB=WTP, AC=MTP, CD=TIM and CE=TIL

Statistical Analysis: All the data were collected and analyzed by using Statistical Product and Service Solution (SPSS) version 19.0 (SPSS, Inc, Chicago, Illinois for Windows). A ***P*** value of 0.05 was set as the level of significance**.**

III. RESULTS

The present study was done among 75 samples (13 male and 62 female) in which, in male 10 samples were from left knee and 3 from right knee, and in female 34 samples from left knee and 28 from right knee, who varied in age from: 45 to 75 years old. The collection of each tibial bone piece from TKA was checked thoroughly, and then measurements was taken for each bone piece and analyzed by means of statistical software. After analysis, it was observed that, according to age, gender and side distribution, the mean length from tibial insertion of PCL to anterior region of the tibial plateau i.e. Width of the Tibial Plateau (WTP) was 43.16±4.621 mm (Table 1, 2 & 3), and the mean length from tibial insertion of PCL to center of tibial plateau i.e. Mid-point of Tibial Plateau/half of WTP (MTP) was 21.58±2.310 mm (Table 1, 2 & 3). The mean length from mid-point of tibial plateau/half of WTP to the medial region of the tibia i.e. Center of the tibial insertion of PCL to the medial region of the tibia (TIM), in male and female were 37.23±3.419 mm and 34.48±3.496 mm respectively (Table 2), in left and right leg were 35.09±3.869 mm and 34.77±3.273 mm respectively (Table 3), and according to age group the mean length was 34.96±3.615 mm (Table 1). The mean length from mid-point of tibial plateau/half of WTP to the lateral region of the tibia i.e. Center of the tibial insertion of PCL to the lateral region of the tibia (TIL), in male and female were 40.54±3.799 mm and 35.92±3.106 mm respectively (Table 2), in left and right leg were 36.77±4.103 mm and 36.65±2.984 mm respectively (Table 3), and according to age group the mean length was 36.72±3.660 mm (Table 1).

Table 1: Showing the mean value of distances according to Age

Ages (45-75 years)	WTP	MTP	TIM	TIL
Ranges (45-59 years)	43.35 ± 6.244	21.68 ± 3.122	34.18 ± 3.988	37.41 ± 3.759
Ranges (60-74 years)	43.10 ± 4.094	21.55 ± 2.047	35.19 ± 3.502	36.52 ± 3.638
Total	43.16 ± 4.621	21.58 ± 2.310	34.96 ± 3.615	36.72 ± 3.660

Table 2: Showing the mean value of distances according to Gender

Gender	Cases	WTP	MTP	TIM	TIL
Male	13	46.31 ± 2.136	23.15 ± 1.068	37.23 ± 3.419	40.54 ± 3.799
Female	62	42.50 ± 4.738	21.25 ± 2.369	34.48 ± 3.496	35.92 ± 3.106
Total	75	43.16 ± 4.621	21.58 ± 2.310	34.96 ± 3.615	36.72 ± 3.660

Statistic		*F*= 7.986 *P*= 0.006	*F*= 7.986 *P*= 0.006	*F*= 6.683 *P*= 0.012	*F*= 21.971 *P*= 0.000

N=Number of Patients
***P*＜0.05 is statistically significant**

Table 3: Showing the mean value of distances according to Leg (Left/Right)

Leg (left/ right)	Cases	WTP	MTP	TIM	TIL
Left Leg	44	42.82 ± 4.384	21.41 ± 2.192	35.09 ± 3.869	36.77 ± 4.103
Right Leg	31	43.65 ± 4.970	21.82 ± 2.485	34.77 ± 3.273	36.65 ± 2.984
Total	75	43.16 ± 4.621	21.58 ± 2.310	34.96 ± 3.615	36.72 ± 3.660

IV. DISCUSSION

The Cruciate ligaments play a major role in stability of knee, these ligaments bind the femur and tibia, so that it prevents the sliding of tibia from femur also helps in rotational movements and it controls the back and forth movements of knee [20]. Most studies have measured the cruciate ligaments in the anatomical position, i.e. with the knee extended. These measurements have been based on the sagittal view, with removal of the femoral condyle [21]. In the present study, the anatomical measurements were based on proximal tibial bone cut-off part during the process of arthrotomy at the time of TKA surgery. Satku et al. [22], according to whom, although the cruciate ligaments have AL and PM fibers, they are not clearly separated. More commonly, the PCL is believed to have a complex structure. According to Girgis and Marshall [4], the PCL consists of two parts but they are inseparable. The most common view presents the ligament as a structure containing two separated bundles which are sometimes referred to as the anterior and posterior parts: aPC and pPC [23], and usually as the AL-PCL and PM-PCL [24-30]. Some studies on the PCL have not described the locations of the AL and PM bands separately [31-33]. Present study has its limitations; we are not analyzing the bundles of posterior cruciate ligaments separately, it is not easy to evaluate the separate bundles from the cutting bone part of tibia. So, we assumed AL and PM bundles as a center of tibial insertion of PCL on tibial plateau and then measurements of various distances were taken in both male and female from both left and right knee among aged Chinese population. Even with similar measurements, the results may show discrepancies if obtained in different manners.

The PCL originates from a large area of the medial femoral condyle and is inserted in a depression between the tibial plateaus called the fossa of the PCL [2]. It is slightly medial to the imaginary axis of knee rotation. The results from anatomical studies on the tibial insertion of the PCL corroborate this affirmation. Lorenz et al. [32] found the center of the tibial insertion of PCL was 45 mm from the lateral edge of the tibial plateau and 43 mm from the medial edge. The result from the present study demonstrated an even more medial position, with the center of the PCL in the tibia at 36.72 mm from the lateral edge and 34.96 mm from the medial edge. Daniel et al. [34] selected eight knees from cadavers and found that the center PCL in the tibia at 40.6 mm from the lateral edge and 32.5 mm from the medial edge. Our measurements were quiet close to that of Daniel et al. but his study and measurements were made with the knee (from cadavers) flexed at 90 degree, with the intention of increasing the applicability of the study to arthroscopic procedure. The present study was made from the tibial cut off bone piece during TKA surgery.

In a study on 10 knees from cadavers using computed tomography, Greiner et al. [35] found that the mean distance between the tibial insertion of the PCL and the medial border of the tibial plateau was 36.6 mm, whereas, in our study, that measurement found was 34.96 mm.

The mean length from center of the tibial insertion of PCL to the medial region of the tibia was 37.23 mm in male and 34.48 mm in female. The mean length from center of the tibial insertion of PCL to the lateral region of the tibia was 40.54 mm in male and 35.92mm in female. Our study reflects the gender differences in mean values; this type of study has been reported only by few authors. Some of the authors described PCL as one entity without any gender differences; several studies have done on separate bundles of PCL. In our study, the obtained values are statistically significant ($P<0.05$). The mean length from center of the tibial insertion of PCL to the medial region of the tibia was 35.09 mm in left and 34.77 mm in right leg. The mean length from center of the tibial insertion of PCL to the lateral region of the tibia was 36.77 mm in left and 36.65 mm right leg. The anatomical location of PCL on tibial plateau of elderly male and female had no significant differences in terms of gender and side distribution. Although many cadaveric studies describe the location of PCL, to our findings no previous study has looked into this subject in vivo which evaluate the anatomical location. Moreover, our study was solemnly done on Chinese patients' elderly aged group (45-75 years), only who were scheduled for TKA surgeries.

The results of the current study are quite similar to previous descriptions of the PCL tibial insertion site. Additionally, the fact that the current study focuses on evaluation of the attachments of the PCL in their entirety rather than focusing on the bundles separately. There are some limitations in this study. It must be noted that our study involved only elderly Chinese patients and subject in vivo not cadaveric studies. This limitation may have caused to the difference found between our study and others. Moreover it might be due to the sample difference between different nationalities. To adequately explain the difference requires a bigger sample.

V. CONCLUSION

The results of this study demonstrate that the tibial insertion of PCL is slightly medial on the tibial plateau of knee joint in both left and right knee in both male and female. So the location of center of the tibial insertion of PCL has no significant differences in terms of gender and side

distribution among elderly (ranges from 45 to 75 years) Chinese population during TKA. It plays a crucial role in understanding the anatomical location of PCL among aged population. More detailed description of the behavior of the ligaments may be found in the references listed below. Understanding the anatomy of the PCL is not only important in treatment of ligamentous injuries but also in total knee arthroplasty.

ACKNOWLEDGMENT

This experiment complies with the current laws of this country. We would like thank to Lanzhou University, and Department of Orthopedics, Department of Nursing, Operation Room, The Second Hospital of Lanzhou University for their assistance in this study.

SOURCE OF FUNDING

No source of funding in any form has been received.

CONFLICTS OF INTEREST

We have no conflicts of interest to declare in association with this paper.

REFERENCES

[1] Yelicharla, A.K.R., U. Gajbe, and B. Singh, Morphometric Study on Cruciate Ligaments Of Knee With Gender Differences: A Cadaveric Study. Asian Pac. J. Health Sci., 2014. 1(3): p. 285-291.

[2] Fanelli, G.C., J.D. Beck, and C.J. Edson, Current concepts review: the posterior cruciate ligament. J Knee Surg, 2010. 23(2): p. 61-72.

[3] GOLDBLATT, J.P. and J.C. RICHMOND, ANATOMY AND BIOMECHANICS OF THE KNEE. Operative treatment in sports medicine, 2003. 11(3): p. 172–186.

[4] Girgis, F.G., J.L. Marshall, and A. Monajem, The cruciate ligaments of the knee joint. Anatomical, functional and experimental analysis. Clin Orthop Relat Res, 1975(106): p. 216-31.

[5] Harner, C.D., et al., Quantitative analysis of human cruciate ligament insertions. Arthroscopy, 1999. 15(7): p. 741-9.

[6] Van Dommelen, B.A. and P.J. Fowler, Anatomy of the posterior cruciate ligament. A review. Am J Sports Med, 1989. 17(1): p. 24-9.

[7] DE, C., W. RF, and W. JJP, The posterior cruciate ligament and posterolateral structures of the knee: anatomy, function, and patterns of injury. Vol. 40. 1991. 249-270.

[8] LC, A., S. JB, and B. FC, Injuries to the ligaments of the knee joint. J Bone Joint Surg 1944. 26(A): p. 503-521.

[9] JC, H., A. JR, and Cross MJ, Classification of knee ligament instabilities Parts I and II. J Bone Joint Surg, 1976. 58(A): p. 159-179.

[10] JC, H., B. JA, and A. JR, Acute tears of the posterior cruciate ligament Results of operative treatment. J Bone Joint Surg, 1980. 62(A): p. 438-450.

[11] JC, K. and G. RW, The posterior cruciate ligament. J Trauma, 1967. 7: p. 367-376.

[12] DL, B., N. FR, and G. ES, Ligamentous restraints to anteriorposterior drawer in the human knee. A biomechancial study. Bone Joint Surg, 1980. 62(A): p. 259-270.

[13] JC, K., R. JH, and W. DM, Posterior cruciate ligament injuries. Orthop Digest, 1979. 7: p. 19-32.

[14] LC, D., Function of the cruciate ligaments in knee stability. J Sports Med, 1974. 2: p. 217-221.

[15] FH, F., H. CD, and J. DL, Biomechanics of knee ligaments: Basic concepts and clinical application. J Bone Joint Surg, 1993. 75: p. 1716-1727.

[16] R, S., Studies on the vasculature of the human knee joint. Acta Anat, 1968. 70: p. 305.

[17] RP, W., Knee joint structure and function. Clin Orthop 1980. 147: p. 7-14.

[18] JC, K., A. IJ, and H. KC, Nerve supply of the human knee and its functional importance. Am J Sports Med, 1982. 7: p. 329-34.

[19] Y, H., et al., Nerve distribution to the human knee joint anatomical and immunohistological study. International Orthopaedics (Sicot), 2004. 24: p. 1-4.

[20] Barrett, G.R., et al., Reconstruction of the anterior cruciate ligament in females: A comparison of hamstring versus patellar tendon autograft. Arthroscopy, 2002. 18(1): p. 46-54.

[21] Anderson, C.J., et al., Arthroscopically pertinent anatomy of the anterolateral and posteromedial bundles of the posterior cruciate ligament. J Bone Joint Surg Am, 2012. 94(21): p. 1936-45.

[22] K, S., C. CN, and S. H, Posterior cruciate ligament injuries. Acta Orthop Scandinav, 1984. 55: p. 26–29.

[23] A, R. and A. AA, PCL reconstruction: in vitro biomechanical comparison of "isometric" versus single and double-bundle "anatomic" grafts. J Bone Joint Surg, 1998. 80(B): p. 173-179.

[24] Baek, G.H., et al., Quantitative analysis of collagen fibrils of human cruciate and meniscofemoral ligaments. Clin Orthop Relat Res, 1998(357): p. 205-11.

[25] Edwards, A., A.M. Bull, and A.A. Amis, The attachments of the fiber bundles of the posterior cruciate ligament: an anatomic study. Arthroscopy, 2007. 23(3): p. 284-90.

[26] Harner, C.D., et al., Comparative study of the size and shape of human anterior and posterior cruciate ligaments. J Orthop Res, 1995. 13(3): p. 429-34.

[27] Harner, C.D., et al., The human posterior cruciate ligament complex: an interdisciplinary study. Ligament morphology and biomechanical evaluation. Am J Sports Med, 1995. 23(6): p. 736-45.

[28] Hughston, J.C., et al., Acute tears of the posterior cruciate ligament. Results of operative treatment. J Bone Joint Surg Am, 1980. 62(3): p. 438-50.

[29] Race, A. and A.A. Amis, The mechanical properties of the two bundles of the human posterior cruciate ligament. J Biomech, 1994. 27(1): p. 13-24.

[30] Zaffagnini, S., et al., Computer analysis of PCL fibres during range of motion. Knee Surg Sports Traumatol Arthrosc, 2004. 12(5): p. 420-8.

[31] Racanelli, J.A. and D. Drez, Jr., Posterior cruciate ligament tibial attachment anatomy and radiographic landmarks for tibial tunnel placement in PCL reconstruction. Arthroscopy, 1994. 10(5): p. 546-9.

[32] Lorenz, S., et al., Radiological evaluation of the anterolateral and posteromedial bundle insertion sites of the posterior cruciate ligament. Knee Surg Sports Traumatol Arthrosc, 2009. 17(6): p. 683-90.

[33] Lee, Y.S., et al., Posterior cruciate ligament tibial insertion anatomy and implications for tibial tunnel placement. Arthroscopy, 2011. 27(2): p. 182-7.

[34] Cho, D.K., et al., Anatomical study of the posterior cruciate ligament with the knee flexed at 90 degrees. Rev Bras Ortop, 2014. 49(5): p. 494-8.

[35] Greiner, P., et al., Computed tomography evaluation of the femoral and tibial attachments of the posterior cruciate ligament in vitro. Knee Surg Sports Traumatol Arthrosc, 2011. 19(11): p. 1876-83.