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Effect of Anterior Cruciate Ligament Reconstruction with Hamstring Tendons on Insall-Salvati Index and Anterior Knee Pain

Ефекти реконструкције предње унакрсне везе затколеним тетивама на Инсол-Салватијев индекс и бол у колену

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SUMMARY

Introduction/Objective The aim of this study was to evaluate the relationship between anterior knee pain and Insall-Salvati ratio after anterior cruciate ligament (ACL) reconstruction with hamstring tendon.

Methods We have evaluate 39 patient that had an ACL reconstruction surgery with hamstring tendon retrospectively. 14 patient had anterior knee pain at the and of the first year of the surgery. All the patient were evaluated for Insall-Salvati ratio preoperatively and postoperatively. Patients were evaluated at the end of the first year after the surgery with Lysholm score and Tegner activity scale. Patients preoperative and postoperative measurements were analyzed by using the Wilcoxon test and differences between patients with anterior knee pain and without pain was analyzed by the Mann-Whitney *U* test.

Results Mean Insall-Salvati ratio was found preoperatively 0,91±0,1 and postoperatively 0,85±0,09 ($p \leq 0,05$). Mean Tegner activity score was 8,56±1,04 and mean Lysholm score was 87,36±9,42 in the group without anterior knee pain. Mean Tegner activity score was 7,21±0,97 and mean Lysholm score was 74,43±9,94 in the group with anterior pain. There is an decrease in İnsall-Salvati ratio as a result of the surgery. But patients with anterior knee pain had lower values of İnsall-Salvati ratio preoperatively.

Conclusion Preoperatively low İnsall-Salvati ratio can be premised indicator of anterior knee pain in the early period after ACL reconstruction with hamstring tendons. Mean Tegner activity score and mean Lysholm score have higher values in the group without anterior pain post operatively.

Keywords: anterior cruciate ligament, reconstruction; Insall-Salvati Index; hamstring tendons

САЖЕТАК

Увод/Циљ Циљ овог рада је био процена односа бола у колену и Инсол-Салватијевог односа после реконструкције предње унакрсне везе (ПУВ) затколеним тетивама.

Методе Ретроспективно је анализирано 39 испитаника са реконструкцијом ПУВ. Код свих испитаника одређени су Инсол-Салватијев индекс пре и постоперативно, а годину дана после операције Лисхолмов скор и Тегнерова скала активности. Бол у колену је имало њих 14 у години после операције. Пре и постоперативне вредности анализиране су Вилкоксоновим тестом, а Ман-Витнијевим У тестом разлике код испаника са и без болова.

Резултати Инсол-Салватијев индекс је био преоперативно 0,91±0,1, а постоперативно 0,85±0,09 ($p \leq 0,05$). У групи без болова у колену вредност Тегнерове скале била је 8,56±1,04, а Лисхолмовог скора 87,36±9,42. Угрупи са болом у колену вредност Тегнерове скале била је 7,21±0,97, а Лисхолмовог скора била је 74,43±9,94. Постоји смањење Инсол-Салватијевог индекса као резултат операције, али болесници са боловима у колену су преоперативно имали ниже вредности овог индекса.

Закључак Преоперативно низак Инсалл-Салватијев индекс може бити значајан индикатор бола у колену у раном периоду после реконструкције ПУВ са затколеним тетивама. Вредности Тегнерове скале активности и Лисхолмовог скора имају су веће у групи без бола после операције.

Кључне речи: предња унакрсна веза, реконструкција; Инсол-Салвати индекс; затколене тетиве;

INTRODUCTION

Anterior cruciat ligament (ACL) injuries are commonly seen injuries among knee joint especially in young population [1]. Reconstruction of the ACL is a well-established procedure with hamstring tendons. Approximately 200,000 ACL reconstructions are performed annually in the United States. ACL injury incidence is one in 3,000 per year [2]. There are two main goals of ACL reconstruction. First one is restoration of functional stability without pain. Second one is to prevent degenerative changes of the knee joint. There are several defined surgical technics for the reconstruction of ACL tear. As a result of these reconstruction technics several complications can be seen. Anterior knee pain is one of the important complication that can be seen after acl reconstruction.

Etiology of anterior knee pain contains chondromalacia of the patella, patellar tendinitis, lateral compression syndrome, quadriceps tendinitis and patella maltracking. Especially it can be seen after the reconstruction that is done with patellar tendon.

Insall salvati ratio is used for the determinantion of the patellar position with patellar tendon and patellar length ratio. There is relation with patella position and anterior knee pain. Shortening of the patellar tendon can be the reason for patellofemoral pain. As a result of the patellar tendon shortening flexion contracture can be occure. It may explain the relation between patella baja and patellofemoral pain [3]. An other theory for the etiology of patellofemoral pain or anterior knee pain is quadriceps inhibition. According to this theory there is an alteration of patellar tracking when there is contraction of quadriceps in the ACL-deficient knee near extension. Anterior translation of the tibia can push the patella laterally and this force change patellar contact areas and anterior knee pain can be occure as a result of this contact area diferences. Third reason is the general inflammation of the joint which can be the reason of the decreased patellar mobility and increased patellar compression forces[4].

There have been technical changes and advances during recent years for the treatment of ACL tear and many studies showed successful results of arthroscopic ACL reconstruction[5]. Hamstring tendon as autografts are the popular treatment modality for acl reconstruction nowadays. Anterior knee pain is an important problem that can be faced after acl reconstruction with hamstring tendon also.

Primery goal of this retrospective study is to compare Insall salvati ratio of the ACL reconstructed knee pre operatively and post operatively. Secondery goal is to search the relationship between anterior knee pain and Insall salvati ratio.

METHODS

Study design

This study was conducted in accordance with the ethical standards of the institutional committee and with the Helsinki Declaration of 1975, as revised in 2013. Following institutional review board approval for our research with number 10840098- 604.01.01-E.22402.We have evaluate 39 patients who underwent ACL reconstruction surgery with Hamstring tendon between january 2014 and january 2015 retrospectively. There were 3 females and 36 male patient. Mean age of the patients were 27,8 years(18- 47) at the time of surgery. We evaluated 39 patients as two groups, with and without anterior knee pain.14 patient had persistent anterior knee pain at the and of the first year of the surgery. Pre operative and post operative Insall-Salvati ratio was determined on lateral x rays. Post operatively Lysholm and Tegner activity scale scores of the patients were collected.

Radiological measurements

The measurement of the patellar height was based on the Insall-Salvati method and was determined by the ratio of the patellar tendon length over the diagonal distance of the patella bone on a lateral view radiograph with the knee at 20° to 30° of flexion. The normal value of patellar height was 1.0±0.2 SD. Patella alta is defined when the ratio is greater than 1,2 and patella baja is defined when the ratio is 0.8 or less [6].

Clinical outcome measurements

Patients were evaluated at the end of the first year after the surgery with Lysholm score and Tegner activity scale. Tegner activity scale is used to measure the outcomes of knee ligament injuries [7]. The Lysholm score determines the functional status of the patient [8]. The Tegner activity scale is extension of the Lysholm score that gives information about activity level [8].

Surgical technique

All the ACL reconstructions were performed by using hamstring tendon as autogreft. The hamstring tendon (semitendinosus and gracilis tendons) were harvested. Double loops (four-stranded) graft of hamstring tendon was prepared. Femoral tunnel is prepared through the anteromedial arthroscopic portal. We prefere transportal technique because transportal technique provides improved position of tibial and femoral tunnels when compared with the trans-tibial technique[9]. Femoral side fixation was provided with endobutton tibial side fixcation was provided with bio screws and staples.

Postoperative treatment and evaluation

All the patients used knee braces in full extensions for the operated knee after the surgery. Early range of motion exercise and quadriceps muscle strengthening was encouraged in all the patients. All the patients were included the same physiotherapy program.

Statistical analysis

Compliance with the normal distribution of the data has been tested and non-parametric methods used. Because they are not normally distributed. Patients preoperative and postoperative Insall-Salvati values and clinical outcome measurements were analyzed by using the Wilcoxon test and differences between patients with anterior knee pain and without pain was analyzed by the Mann Whitney U test. 95% confidence intervals and $p < 0.05$ was considered statistically significant.

RESULTS

Radiological results

Pre operatively mean Insall-Salvati ratio was found 0,91± 0,1. Post operatively mean Insall-Salvati ratio was found 0,85±0,09.($p \leq 0,05$) There is a statistically significant diference between the pre operative and post operative Insall-Salvati ratio. Mean Insall-Salvati ratio was found 0,93±0,1 in the group without anterior pain pre operatively. Mean Insall-Salvati ratio was found 0,86±0,09 in the

group with anterior knee pain pre operatively. Mean Insall-Salvati ratio was found 0,89±0,8 in the group without anterior knee pain post operatively. Mean Insall-Salvati ratio was found 0,79±0,7 in the group with anterior knee pain post operatively. There is a statistically significant difference between the pre operative and post operative Insall-Salvati ratio between the groups also. (pre p=0,025 post p=0,002) There is an decrease in İnsall-Salvati ratio as a result of the surgery. But patients with anterior pain had lower values of İnsall-Salvati ratio pre operatively. Pre operatively low İnsall-Salvati ratio can be premised indicator of anterior knee pain after ACL reconstruction with hamstring tendons. Among these 39 patient 11 had less Insall-Salvati ratio than 0,8. But these 11 patient had less Insall-Salvati ratio than 0,8 pre operatively also.

Clinical outcome measurements

Mean Tegner activity score was 8,08±1,2 and mean Lysholm score was 82,72±11,37 post operatively. Mean Tegner activity score was 8,56±1,04 and mean Lysholm score was 87,36±9,42 in the group without anterior knee pain. Mean Tegner activity score was 7,21±0,97 and mean Lysholm score was 74,43±9,94 in the group with anterior pain. Mean Tegner activity score and mean Lysholm score have higher values in the group witout anterior pain. There is a statistically significant diference in post operative Mean Tegner activity score and mean Lysholm score between two groups. (p≤0,001)

DISCUSSION

According to the study that was done by Hantes et. al, patellar tendon shortening can be seen after harvesting the patellar tendon for anterior cruciate ligament reconstruction. But there is no shortening of patellar tendon length after harvesting of the hamstring tendons for anterior cruciate ligament reconstruction. Authors state that there was no significantly difference between functional outcome and incidence of patella baja between the two groups as a result of the study [10]. But our results indicates a decrease in Insall-Salvati ratio between pre operative and post operative values in the ACL deficient knees treated with hamstring tendons.

After an ACL injury patellar tendon length elongation can be seen. This elongation increases the Insall-Salvati ratio. Increased patellar tendon length can be the reason for quadriceps muscle weakness after ACL injury. The patellar tendon length has an affect on biomechanical properties of the patellar articulation [11]. An increased length of the patellar tendon can cause an increase in quadriceps slack length which reduces quadriceps mechanical advantage [12]. Our results shows patellar tendon length shortening after ACL reconstruction because of the decrease in Insall-Salvati ratio between pre operative and post operative values. After the ACL reconstruction and quadriceps muscle strengthening physiotherapy program there can be shortening of patellar tendon length. It can be the reason why we have detected patellar tendon shortening between pre operative and post operative values.

Insall Salvati ratio is low for patella infera. Patella infera is noted as an risk factor for ACL injury in adults [13]. As a result of an other study that was evaluated the ACL injury in children, there is a significant association between an ACL tear and increased patellar tendon length with a greater Insall-Salvati ratio. For this reason patella alta can be a risk factor for ACL injuries in pediatric patients [14]. Mean pre operative value of Insall Salvati ratio is 0,91± 0,1 according to our study.

Patients with higher body mass index, low physical performance, low quality of life, kinesiophobia and late return to sportive activities have patello femoral pain after ACL reconstruction. Older age at the time of ACL reconstruction was only predictor for patellofemoral pain [15]. Preoperative quadriceps strength, age, sex, and knee pain are the important factors to achieve sufficient quadriceps strength recovery at the time of returning to sports activities [16]. There is no statistical study about the relationship between age at the time of the surgery and anterior knee pain after ACL reconstruction in our study. But in general terms we have detected anterior knee pain in all age groups.

Patellofemoral osteoarthritis is an other important factor for anterior knee pain after ACL reconstruction and it is associated with decreased functional performance [17]. Patellofemoral osteoarthritis was detected in 26 % of the patients after 12 years of ACL reconstruction. Increased age and tibiofemoral osteoarthritis are predisposing factors for patellofemoral osteoarthritis after ACL reconstruction [18]. Excessive lateral pressure syndrom and patellar lateralization are strongly correlated with anterior knee pain after ACL reconstruction [19]. Abnormal orientation in the coronal plane and twist of the patellar tendon can be the reason of patellar rotation. As a result of this rotation the contact pressure of the lateral petollofemoral joint increases which may predispose degenerative changes and anterior knee pain after ACL reconstruction [20]. After excision of the ACL in cadaveric knees lateral shift and tilt of the patella increases as a result of this biomechanical changes, contact area and pressure on patellofemoral joint decreases [21,22]. We have not evaluated the relationship patellofemoral osteoarthritis in our patients with anterior knee pain. Also our follow-up period is short to make a such inferences.

Increased blood flow in the infrapatellar fat pad is an importanat factor for anterior knee pain after ACL reconstruction with HT autografts and ultrasound evaluation can be useful for to determine the etiology of the anterior knee pain [23]. But we have not performed ultrasound to our patients with anterior knee pain after ACL reconstruction.

According to the study that was done by Chase et. al patella infera has no effect on postoperative anterior knee pain. But loss of knee extension of greater than 5 degrees correlated with anterior knee pain [24]. There is statistically significant difference between the results of Lysholm and Tegner activity scale in both groups with anterior pain and without anterior knee pain. Also we have found statistically significant difference between patella infera and anterior knee pain after ACL reconstruction with hamstring tendons.

There are lots of studies which compare graft selection and anterior knee pain after ACL reconstruction in the literature. Increased anterior knee pain and kneeling pain had been reported after ACL reconstruction with bone patellar tendon bone autografts when compared with hamstring tendon autografts [25]. But some study results show that there were no significant differences in terms of anterior anterior knee pain after ACL reconstruction with bone patellar tendon bone autografts or hamstring tendon autografts [26]. In a study that was done by Hantes et. al there is greater pain upon kneeling in the group with hamstring tendon grafts than patellar tendon grafts [27]. There are 14 patients with anterior knee pain that had ACL reconstrustion with hamstring tendons in our series. There was no group that was treated with bone patellar tendon bone autografts in our study. There is restriction for the relationship between anterior knee pain and graft selection for ACL reconstruction in our study.

Hantes et.al compared the patellar tendon length in two groups after ACL reconstruction First group include the patients that were treated with patellar tendon second group include the patients that were treated with hamstring tendons. Operated knee values were compared to the non-operated side. They detected a significant 4.2 mm or 9.7% patellar tendon shortening in patellar tendon group and a non-significant 1.14 mm or 2.6% shortening in hamstrings group and as a result of the study incidence of patella baja and overall functional outcome was not significantly different between the two group [10]. We have detected patellar tendon shortening after ACL reconstruction with hamstring tendon also but we evaluated the operated knees. We did not compared the operated side to the healty side. This is an important restriction of our study.

CONCLUSIONS

There is an decrease in İnsall-Salvati ratio as a result of the surgery. But patients with anterior knee pain had lower values of İnsall-Salvati ratio pre operatively. Pre operatively low İnsall-Salvati ratio can be premised indicator of anterior knee pain in the early period after ACL reconstruction with hamstring tendons. Mean Tegner activity score and mean Lysholm score have higher values in the group witout anterior pain post operatively.

REFERENCES

1. Gianotti SM, Marshall SW, Hume PA, Bunt L. Incidence of anterior cruciate ligament injury and other knee ligament injuries: a national population-based study. J Sci Med Sport. 2009; 12(6): 622–7.
2. National Institutes of Health (NIH) (2007). Prognosis and predictors of ACL reconstruction–a multicenter cohort study. National Institute of Arthritis and Musculoskeletal and Skin Diseases (NIAMS), Vanderbilt University, United States. (Accessed March 1, 2011). Available at: http://clinicaltrials.gov/ct2/show/NCT00463099.
3. Sachs RA, Daniel DM, Stone ML, Garfein RF. Patellofemoral problems after anterior cruciate ligament reconstruction. Am J Sports Med. 1989; 17(6): 760–5.
4. Steiner ME. Surgical Management of Anterior Cruciate Ligament Injuries. In: McKeon BP, Bono JV, Richmond JC, eds. Knee Arhroscopy: Springer; 2009. p. 128–52.
5. Prodromos CC, Han YS, Keller BL, Bolyard RJ. Stability results of hamstring anterior cruciate ligament reconstruction at 2- to 8-year follow-up. Arthroscopy. 2005; 21(2): 138–46.

6. Insall J, Salvati E. Patella position in the normal knee joint. Radiology. 1971; 101: 101–4.
7. Briggs KK, Lysholm J, Tegner Y, Rodkey WG, Kocher MS, Steadman JR. The reliability, validity, and responsiveness of the Lysholm score and Tegner activity scale for anterior cruciate ligament injuries of the knee: 25 years later. Am J Sports Med. 2009; 37(5): 890–7.
8. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. Clin Orthop Relat Res. 1985; 198: 43–9.
9. Yau WP, Fok AW, Yee DK. Tunnel positions in transportal versus transtibial anterior cruciate ligament reconstruction: a case-control magnetic resonance imaging study. Arthroscopy. 2013; 29(6): 1047–52.
10. Hantes ME, Zachos VC, Bargiotas KA, Basdekis GK, Karantanas AH, Malizos KN. Patellar tendon length after anterior cruciate ligament reconstruction: a comparative magnetic resonance imaging study between patellar and hamstring tendon autografts. Knee Surg Sports Traumatol Arthrosc. 2007; 15(6): 712–9.
11. van Eijden TM, Kouwenhoven E, Weijs WA. Mechanics of the patellar articulation: effects of patellar ligament length studied with a mathematical model. Acta Orthop Scand. 1987; 58(5): 560– 6.
12. Draganich LF, Andriacchi TP, Andersson GB. Interaction between intrinsic knee mechanics and the knee extensor mechanism. J Orthop Res. 1987; 5(4): 539–47.
13. Lin CF, Wu JJ, Chen TS, Huang TF. Comparison of the Insall-Salvati ratio of the patella in patients with and without an ACL tear. Knee Surg Sports Traumatol Arthrosc. 2005; 13(1): 8–11.
14. Degnan AJ, Maldjian C, Adam RJ, Fu FH, Didomenico M. Comparison of Insall-Salvati ratios in children with an acute anterior cruciate ligament tear and a matched control population. AJR Am J Roentgenol. 2015; 204(1): 161–6.
15. Culvenor AG, Collins NJ, Vicenzino B, Cook JL, Whitehead TS, Morris HG, et al. Predictors and effects of patellofemoral pain following hamstring-tendon ACL reconstruction. J Sci Med Sport. 2016; 19(7): 518–23.
16. Ueda Y, Matsushita T, Araki D, Kida A, Takiguchi K, Shibata Y, et al. Factors affecting quadriceps strength recovery after anterior cruciate ligament reconstruction with hamstring autografts in athletes. Knee Surg Sports Traumatol Arthrosc. 2016. [DOI: 10.1007/s00167-016-4296-6]
17. Culvenor AG, Lai CC, Gabbe BJ, Makdissi M, Collins NJ, Vicenzino B, et al. Patellofemoral osteoarthritis is prevalent and associated with worse symptoms and function after hamstring tendon autograft ACL reconstruction. Br J Sports Med. 2014; 48(6): 435–9.
18. Øiestad BE, Holm I, Engebretsen L, Aune AK, Gunderson R, Risberg MA. The prevalence of patellofemoral osteoarthritis 12 years after anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc. 2013; 21(4): 942–9.
19. Osowska K, Fabiś J, Fabiś A, Grodzka M, Zwierzchowski JT. The evaluation of the influence of selected patellofemoral joint geometry indicators observed in magnetic resonance imaging on the incidence of anterior knee pain in patients after anterior cruciate ligament reconstruction using hamstrings. Pol Orthop Traumatol. 2013; 78: 247–50.
20. Van de Velde SK, Gill TJ, DeFrate LE, Papannagari R, Li G. The effect of anterior cruciate ligament deficiency and reconstruction on the patellofemoral joint. Am J Sports Med. 2008; 36(6): 1150–9.
21. Hsieh YF, Draganich LF, Ho SH, Reider B. The effects of removal and reconstruction of the anterior cruciate ligament on patellofemoral kinematics. Am J Sports Med. 1998; 26(2): 201–9.
22. Hsieh YF, Draganich LF, Ho SH, Reider B. The effects of removal and reconstruction of the anterior cruciate ligament on the contact characteristics of the patellofemoral joint. Am J Sports Med. 2002; 30(1): 121–7.
23. Kanamoto T, Tanaka Y, Yonetani Y, Kita K, Amano H, Kusano M, et.al. Anterior knee symptoms after double-bundle ACL reconstruction with hamstring tendon autografts: an ultrasonographic and power Doppler investigation. Knee Surg Sports Traumatol Arthrosc. 2015; 23(11): 3324–9.
24. Chase JM, Hennrikus WL, Cullison TR. Patella infera following arthroscopic anterior cruciate ligament reconstruction. Contemp Orthop. 1994; 28(6):487–93. PMID:10147220
25. Xie X, Xiao Z, Li Q, Zhu B, Chen J, Chen H, et.al. Increased incidence of osteoarthritis of knee joint after ACL reconstruction with bone-patellar tendon-bone autografts than hamstring autografts: a meta-analysis of 1,443 patients at a minimum of 5 years. Eur J Orthop Surg Traumatol. 2015; 25(1): 149–59.
26. Heijne A, Hagströmer M, Werner S. A two- and five-year follow-up of clinical outcome after ACL reconstruction using BPTB or hamstring tendon grafts: a prospective intervention outcome study. Knee Surg Sports Traumatol Arthrosc. 2015; 23(3): 799–807.
27. Shi DL, Yao ZJ. Knee function after anterior cruciate ligament reconstruction with patellar or hamstring tendon: a meta-analysis. Chin Med J (Engl). 2011; 124(23): 4056–62.

