

## ORIGINAL ARTICLE / ОРИГИНАЛНИ РАД

# Effect of anterior cruciate ligament reconstruction with hamstring tendons on Insall–Salvati index and anterior knee pain

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**SUMMARY**

**Introduction/Objective** The relationship between anterior knee pain and the Insall–Salvati ratio after anterior cruciate ligament (ACL) reconstruction with hamstring tendon were evaluated in this study.

**Methods** We evaluated 39 patients that had an ACL reconstruction surgery with hamstring tendon. All the patients were evaluated for the Insall–Salvati ratio preoperatively and postoperatively. Fourteen patients had anterior knee pain at the end of the first year after the surgery. The patients were evaluated at the end of the first year after the surgery with the Lysholm score and the Tegner activity scale. The patients' preoperative and postoperative measurements were analyzed by using the Wilcoxon test, and the differences between the patients with anterior knee pain and those without it were analyzed by the Mann–Whitney U test.

**Results** Preoperatively, mean Insall–Salvati ratio was found to be  $0.91 \pm 0.1$ , whereas postoperative ratio was  $0.85 \pm 0.09$  ( $p \leq 0.05$ ). In the group without anterior knee pain, the mean Tegner activity score was  $8.56 \pm 1.04$ , and the mean Lysholm score was  $87.36 \pm 9.42$ . The mean Tegner activity score was  $7.21 \pm 0.97$  and the mean Lysholm score was  $74.43 \pm 9.94$  in the group with anterior pain. There was a decrease in the Insall–Salvati ratio as a result of the surgery, but patients with anterior knee pain had lower values of the Insall–Salvati ratio preoperatively.

**Conclusion** Low preoperative Insall–Salvati ratio can be an indicator of anterior knee pain in the early period after ACL reconstruction with hamstring tendons. The mean Tegner activity score and the mean Lysholm score have higher values in the group without anterior pain postoperatively.

**Keywords:** anterior cruciate ligament, reconstruction; Insall–Salvati index; hamstring tendons

**INTRODUCTION**

Anterior cruciate 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. The first one is the restoration of functional stability without pain. The second one is to prevent degenerative changes of the knee joint. There are several defined surgical techniques for the reconstruction of an ACL tear. As a result of these reconstruction techniques, several complications can be seen. Anterior knee pain is an important complication that can be seen after ACL reconstruction. Etiology of anterior knee pain includes chondromalacia of the patella, patellar tendinitis, lateral compression syndrome, quadriceps tendinitis, and patella maltracking. It can especially be seen after the reconstruction done with patellar tendon.

The Insall–Salvati ratio is used for determining the patellar position with patellar tendon and patellar length ratio. There is a relation between 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 occur. This may explain the relation between the patella baja and patellofemoral pain [3]. Another theory for the etiology of patellofemoral pain or anterior knee pain is the quadriceps inhibition. According to this theory, there is an alteration of patellar tracking when quadriceps contract in the ACL-deficient knee near the extension. Anterior translation of the tibia can push the patella laterally and this force changes patellar contact areas and anterior knee pain can occur as a result of these contact area differences. The third reason is the general inflammation of the joint, which can be the reason for 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 tendons as autografts are a popular treatment modality for ACL reconstruction nowadays. Anterior knee pain is an important problem that can also be faced after ACL reconstruction with a hamstring tendon.

The primary goal of this retrospective study is to compare the Insall–Salvati ratio of the ACL reconstructed knee preoperatively and

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postoperatively. The secondary goal is to investigate the relationship between the anterior knee pain and the 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 the institutional review board approval No. 10840098-604.01.01-E.22402. We retrospectively evaluated 39 patients who underwent ACL reconstruction surgery with the hamstring tendon graft between January 2014 and January 2015. There were three female and 36 male patients. The mean age of the patients was 27.8 years (the range being 18–47 years) at the time of surgery. We evaluated 39 patients as two groups – the first one comprised patients with anterior knee pain, and the second one those without it. Fourteen patients had persistent anterior knee pain one year after the surgery. Preoperative and postoperative Insall–Salvati ratio was determined by lateral X-ray imaging. Postoperative 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 20–30° of flexion. The normal value of the patellar height was  $1.0 \pm 0.2$  SD. Patella alta is defined as the ratio greater than 1.2, and patella baja as the ratio of 0.8 or less [6].

### Clinical outcome measurements

The patients were evaluated at the end of the first year after the surgery with the Lysholm score and the Tegner activity scale. The Tegner activity scale is used to measure the outcome of knee ligament injuries [7]. The Lysholm score determines the functional status of the patient [8]. The Tegner activity scale is an 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 autograft. The hamstring tendons (semitendinosus and gracilis tendons) were harvested. Double-loop (four-stranded) grafts of the hamstring tendons were prepared. Femoral tunnel is prepared through the anteromedial arthroscopic portal. We prefer the transportal technique because it provides an improved position of tibial and femoral tunnels when compared with the trans-tibial technique [9]. Femoral side fixation was provided with an endobutton, while tibial side fixation was provided with bio-screws and staples.

## Postoperative treatment and evaluation

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

### Statistical analysis

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

## RESULTS

### Radiological results

Preoperative mean Insall–Salvati ratio was found to be  $0.91 \pm 0.1$ . Postoperative mean Insall–Salvati ratio was  $0.85 \pm 0.09$  ( $p \leq 0.05$ ). There was a statistically significant difference between the preoperative and postoperative Insall–Salvati ratio. The mean Insall–Salvati ratio was found to be  $0.93 \pm 0.1$  in the group without anterior pain preoperatively. The mean Insall–Salvati ratio was  $0.86 \pm 0.09$  in the group with anterior knee pain preoperatively. Postoperatively, the mean Insall–Salvati ratio was  $0.89 \pm 0.8$  in the group without anterior knee pain, while the mean Insall–Salvati ratio was  $0.79 \pm 0.7$  in the group with anterior knee pain. There was also a statistically significant difference between the preoperative and postoperative Insall–Salvati ratio between the groups (pre:  $p = 0.025$ ; post:  $p = 0.002$ ). There was a decrease in the Insall–Salvati ratio as a result of the surgery, but patients with anterior pain had lower values of the Insall–Salvati ratio preoperatively. Low preoperative Insall–Salvati ratio can be an indicator of anterior knee pain after ACL reconstruction with hamstring tendons. Among these 39 patients, 11 had the Insall–Salvati ratio less than 0.8. However, these 11 patients also had the Insall–Salvati ratio less than 0.8 preoperatively.

### Clinical outcome measurements

The mean Tegner activity score was  $8.08 \pm 1.2$  and the mean Lysholm score was  $82.72 \pm 11.37$  postoperatively. The mean Tegner activity score was  $8.56 \pm 1.04$  and the mean Lysholm score was  $87.36 \pm 9.42$  in the group without anterior knee pain. The mean Tegner activity score was  $7.21 \pm 0.97$  and the mean Lysholm score was  $74.43 \pm 9.94$  in the group with anterior pain. The mean Tegner activity score and the mean Lysholm score had higher values in

the group without anterior pain. There was a statistically significant difference in the postoperative mean Tegner activity score and the mean Lysholm score between the two groups ( $p \leq 0.001$ ).

## DISCUSSION

According to the study done by Hantes et al. [10], patellar tendon shortening can be seen after harvesting the patellar tendon for anterior cruciate ligament reconstruction. However, there is no shortening of the patellar tendon after harvesting the hamstring tendons for anterior cruciate ligament reconstruction. Authors stated that there was no significant difference between functional outcome and incidence of patella baja between the two groups [10]. Our results, on the other hand, indicate a decrease in the Insall-Salvati ratio between preoperative and postoperative 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 an ACL injury. The patellar tendon length has an effect 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 show patellar tendon shortening after ACL reconstruction because of the decrease in the Insall-Salvati ratio between preoperative and postoperative 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 preoperative and postoperative values.

The Insall-Salvati ratio is low for patella baja, which is noted as a risk factor for ACL injury in adults [13]. As a result of another study that evaluated ACL injuries in children, there is a significant association between an ACL tear and the 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 preoperative value of the Insall-Salvati ratio is  $0.91 \pm 0.1$  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 important factors to achieve sufficient quadriceps strength recovery at the time of returning to sports activities [16]. In our study, there is no statistical evaluation of the relationship between the age at the time of the surgery and anterior knee pain after ACL reconstruction. But in general terms, we detected anterior knee pain in all age groups.

Patellofemoral osteoarthritis is another 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 patients 12 years after ACL reconstruction. Increased age and tibiofemoral osteoarthritis are predisposing factors for patellofemoral osteoarthritis after ACL reconstruction [18]. Excessive lateral pressure syndrome 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 for patellar rotation. As a result of this rotation, the contact pressure of the lateral patellofemoral 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 these biomechanical changes, contact area and pressure on the patellofemoral joint decreases [21, 22]. We did not evaluate the relationships of patellofemoral osteoarthritis in our patients with anterior knee pain. Also, our follow-up period was too short to make such inferences.

Increased blood flow in the infrapatellar fat pad is an important factor for anterior knee pain after ACL reconstruction with hamstring tendon autografts, and ultrasound evaluation can be useful for determining the etiology of the anterior knee pain [23]. However, we did not perform ultrasound evaluation of our patients with anterior knee pain after ACL reconstruction.

According to the study by Chase et al. [24], patella baja has no effect on postoperative anterior knee pain. But the loss of knee extension greater than  $5^\circ$  correlates with anterior knee pain [24]. There is a statistically significant difference in the results of the Lysholm score and the Tegner activity scale in between the group with anterior pain and the one without it. Also, we have found statistically significant difference between patella baja and anterior knee pain after ACL reconstruction with hamstring tendons.

There are numerous studies which compare graft selection and anterior knee pain after ACL reconstruction. Increased anterior knee pain and kneeling pain have 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 knee pain after ACL reconstruction with bone – patellar tendon – bone autografts or hamstring tendon autografts [26]. In a study by Shi and Yao [27] there is greater pain upon kneeling in the group with hamstring tendon grafts than in the one with patellar tendon grafts. In our series there were 14 patients with anterior knee pain that had ACL reconstruction with hamstring tendons. There was no group that was treated with bone – patellar tendon – bone autografts in our study. In our study there is a restriction for the relationship between anterior knee pain and graft selection for ACL reconstruction.

Hantes et al. [10] compared the patellar tendon length in two groups after ACL reconstruction. The first group included patients that were treated with patellar tendons; the second group included patients treated with hamstring tendons. Operated knee values were compared to the non-operated side. They detected a significant 4.2 mm (9.7%)

patellar tendon shortening in the patellar tendon group and a non-significant 1.14 mm (2.6%) shortening in the hamstring tendon group and as a result of the study incidence of patella baja and overall functional outcome was not significantly different between the two groups [10]. We also detected patellar tendon shortening after ACL reconstruction with the hamstring tendon, but we evaluated the operated knees. We did not compare the operated side to the healthy side. This is an important restriction of our study.

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## CONCLUSION

There is a decrease in the Insall–Salvati ratio as a result of the surgery. However, patients with anterior knee pain had lower values of the Insall–Salvati ratio preoperatively. Preoperatively low Insall–Salvati ratio can be an indicator of anterior knee pain in the early period after ACL reconstruction with hamstring tendons. The mean Tegner activity score and the mean Lysholm score have higher values in the group without anterior pain postoperatively.

## Ефекти реконструкције предње унакрсне везе затколеним тетивама на Инсол–Салватијев индекс и бол у колону

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### САЖЕТАК

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

**Метод**е Анализирали смо 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 колону је имало њих 14 у години после операције. Пре и постоперативне вредности анализирани су Вилксоновим тестом, а Ман–Витнијевим У тестом разлике код испитаника са боловима и без њих.

**Резултати** Инсол–Салватијев индекс је преоперативно био  $0,91 \pm 0,1$ , а постоперативно  $0,85 \pm 0,09$  ( $p \leq 0,05$ ). У групи

без болова у колону вредност Тегнерове скале била је  $8,56 \pm 1,04$ , а Лисхолмовог скор  $87,36 \pm 9,42$ . У групи са болом у колону вредност Тегнерове скале била је  $7,21 \pm 0,97$ , а Лисхолмовог скор  $74,43 \pm 9,94$ . Постоји смањење Инсол–Салватијевог индекса као резултат операције, али болесници са боловима у колону су преоперативно имали ниже вредности овог индекса.

**Закључак** Преоперативно низак Инсал–Салватијев индекс може бити значајан индикатор бола у колону у раном периоду после реконструкције ПУВ са затколеним тетивама. Вредности Тегнерове скале активности и Лисхолмовог скор биле су веће у групи без бола после операције.

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