

# Insall-Salvati Ratio after Arthroscopic Anterior Cruciate Ligament Reconstruction with Patellar Tendon Graft

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**Background:** Arthroscopic anterior cruciate ligament (ACL) reconstruction with patellar tendon graft has been considered to be the gold standard treatment of anterior cruciate ligament injuries. Much morbidity could occur after this graft was harvested, such as the patellar tendon length change and anterior knee pain. Insall-Salvati ratio is one of the tools to determine the patella tendon length.

**Objective:** To study the patella tendon length change after arthroscopic ACL reconstruction with patellar tendon graft by using Insall-Salvati ratio.

**Material and Method:** Descriptive study was conducted. Patients who were diagnosed ACL injury and underwent arthroscopic ACL reconstruction with patellar tendon graft were included. All patients had standardized preoperative and postoperative lateral knee radiographs. The patellar tendon length, patellar height, Insall-Salvati ratio and Tegner Lysholm knee score were measured by the same person for all subjects at preoperative and 6 months postoperative period.

**Results:** In a series of 22 patients, the length of the patellar tendon lengthened by an average of 0.95 mm (6 mm shortening to 5 mm lengthening) or 1.82% and not statistically significant ( $p = 0.101$ ). The Insall-Salvati ratio increased by 2.75% (16.32% shortening to 18.6% lengthening) which was also not statistically significant ( $p = 0.218$ ). The Tegner Lysholm knee score was improved to 20.36 (5 to 45), which was statistically significant ( $p < 0.05$ ). The amount of the Insall-Salvati ratio change was not related to Lysholm score ( $p = 0.571$ ).

**Conclusion:** The present study indicated that there was no significant change of patellar tendon length after arthroscopic ACL reconstruction with patellar tendon graft. No correlations with postoperative Insall-Salvati ratio and Tegner Lysholm knee score, however, the clinical results was improved in all of the patients.

**Keywords:** Insall-Salvati ratio, Arthroscopic anterior cruciate ligament reconstruction, Patellar tendon graft, Patellar tendon length, Patellar height, Tegner Lysholm knee score

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The anterior cruciate ligament (ACL) injury is a disease commonly found in the general population. The ACL reconstruction is the gold standard for the treatment. During surgery, the graft, a new tissue will be used to replace the ACL. The use of patellar tendon graft is one of the graft options.

The ACL reconstruction has a variety of treatment goals, such as: to make the knee joint to move normally; to help the patients to return to work as before the injury; and to prevent injury to subsequent treatment, etc. However, it is found that there were complications for the patient in any use of alternative types of graft for the ACL reconstruction.

The current study and reports show the

complications that occur after using the tissue of the patellar tendon graft. It is found that this may causes the anterior knee pain, kneeling pain, knee stiffness, and changes in the nature of the remaining patellar tendon graft, in terms of strength, length, etc<sup>(1-4)</sup>.

Base on the review of relevant literature, it is found that there are many studies about the length of the patellar tendon graft after the anterior cruciate ligament reconstruction, yielding different conclusions.

The present study conducted by Dandy and Desai<sup>(5)</sup> showed that the average length of the patellar tendon graft shortened by 6% and maximum by 10% in 10 patients of 40 cases studied.

Adam et al<sup>(6)</sup> carried out the present study on the length of the patellar tendon graft using radiation measurements. It was found that the length shortened on average by 3.2% in the first 12 weeks after the surgery. Hantes et al<sup>(7)</sup> conducted the present study on the length of the patellar tendon graft after the surgery by

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comparing between the use of the patellar tendon graft and the hamstring tendon as the reconstruction tissue, using MRI as a tool of measurement. It was found that the patellar tendon graft yielded the result of the shortened length by 9.7% in average, while using the hamstring tendon as the replacement tissue showed the shortening length by only 2.6%.

Breitfuss<sup>(1)</sup> reported the shortened patellar tendon graft after the surgery by up to 9.8% in 23 out of 41 patients studied. However, the present study of Robert et al<sup>(4)</sup> on the morphologic change concluded that the use of patellar tendon graft as the reconstruction tissue did not affect the length, width and thickness of the remaining patella tendon.

Moreover, the present study by Shaffer BS and Tibone JE<sup>(8)</sup> concluded that the use of patellar tendon graft as the reconstruction tissue showed no effect on the length. Also, the studies by Shelbourne<sup>(9)</sup> and by Krosser<sup>(10)</sup> reported the shortening of the patellar tendon graft only slightly, of less than 1% and 0.51% respectively.

It can be seen that various studies existing show different conclusions on the morphologic changes in the length. Therefore, the present study is to determine whether the length of the patellar tendon graft has changed or not after the anterior cruciate ligament reconstruction surgery.

### Objective

The present study is to examine the changes in the length of the patellar tendon graft at the reconstruction point (by reporting in the Insall-Salvati ratio) after the arthroscopic ACL reconstruction with patellar tendon graft. Also, this is to further study the relationship of the changed length with the symptoms and the ability to use the knees of the patients after the surgery.

### Material and Method

Descriptive study was used in the present study by investigating and measuring the length of the patellar tendon and patella bone from the radiographic images. The Insall-Salvati ratio, which is the ratio of the patellar tendon and patella bone, was calculated. Also, Tegner-Lysholm score was used before and after the surgery. The populations were the patients who had been diagnosed with ACL injury and were treated with the arthroscopic ACL reconstruction with patellar tendon graft at the Orthopaedic Department, Pramongkutklao Hospital. The inclusion criterias were 1) male patient, aged between 20-40 years,

2) receiving the arthroscopic ACL reconstruction with patellar tendon graft and as the first time operation, 3) having the normal Insall-Salvati ratio before surgery, and 4) having another knee in normal condition. Patients using tissues other than patellar tendon graft for reconstruction and having a record of injuries to other ligaments of the knee receiving the surgery or having a record of being diagnosed with a deficient joint surface in the knee receiving the surgery were excluded from the present study.

The participants were taken the radiographic image of the lateral knee in the 30 degrees flexion before surgery and at 6 months after surgery to measure the length of the patellar tendon and patella bone and to calculate the Insall-Salvati ratio<sup>(11)</sup> (Fig. 1). The measurement and report of this ratio were intended to prevent the errors that may arise from the magnification of the lateral radiograph of the knee at two different times. Also, the Tegner-Lysholm Score was recorded before surgery and after surgery at 6 months.

In terms of the procedures for the treatment in the present study, all participants received the surgical treatment by the same orthopaedist, using the same surgical technique and underwent the same physical therapy and rehabilitation program after the surgery. As for the radiograph of the lateral knee at the 30 degrees flexion, the goniometer was determined to control the consistent flexion of the knee in each radiograph. Also, the Tegner-Lysholm Score was recorded to reassess the knees before surgery and at 6 months after surgery.

### Results

The population consisted of 22 cases participating in the study. All of the patients were male. The average age was 24 years. The average length of the patella tendon before surgery was 48.68 mm and the average length after surgery was 49.64 mm. The average Insall-Salvati ratio before surgery was 1.02 and the average ratio after surgery was 1.04. The average Tegner-Lysholm score before surgery was 71.14 while the average score after surgery was 91.50 (Table 1).

The patellar tendon length showed the changes with an average increase of 0.95 mm in length, representing 1.83% of the length prior to surgery. The Insall-Salvati ratio also showed the changes with an average increase of 0.024, equivalent to 2.75% of the ratio before surgery. And the Tegner-Lysholm score also showed the average increase of 20.36 (Table 2).

By using the Student's paired t-test to analyse the relationship of the Insall-Salvati ratio and the relationship of the Tegner-Lysholm score, before and

after surgery, it was found that the relationship of the Insall-Salvati ratio before and after surgery have no statistically significant relationships ( $p = 0.218$ ). However, the scores of the Tegner-Lysholm before and after surgery yielded the relationships with statistically significant ( $p < 0.05$ ) (Table 2). In terms of the relationship between the changes of the Insall-Salvati ratio and the changes of the Tegner-Lysholm scores using the Correlation coefficient test, it showed that the changes of the Insall-Salvati ratio and the changes of the Tegner-Lysholm scores yielded no statistically significant relationships ( $p = 0.122$ ).

When dividing the patients into groups based on the scores obtained from responding to the Tegner-Lysholm score, the new values were set up based on the ability to use the knee joints as following.

- The score of  $< 65$  = poor
- The score of  $65-83$  = fair
- The score of  $84-90$  = good
- The score of  $> 90$  = excellent

The patients could be categorized as following. Before the surgery, there were 6 cases in the poor level, 12 cases in the fair group, 4 cases in the good category and none in the excellent group. After the surgery, there were none in the poor level, 3 cases in the fair group, 3 cases in the good category and 16 cases in the excellent group. As for the correlation analysis using the Wilcoxon test, it was found that the scores of the Tegner-Lysholm before and after surgery yielded the statistically significant relationships ( $p < 0.001$ ) (Table 3).

## Discussion

The length of the patellar tendon after they were harvested for the arthroscopic ACL reconstruction with patellar tendon graft has 6% changes in length<sup>(6)</sup>. In the present study, there were six patients (6/22, 27.27%) showing the percentage of the change in the patella tendon length of more than 6%.

In terms of the Insall-Salvati ratio of the knee joint which has the normal range of  $0.8-1.2$ <sup>(11)</sup> after the arthroscopic anterior cruciate ligament reconstruction with patellar tendon graft, based on the present study, it was found that the Insall-Salvati ratio changed with the an average of  $0.024$ , minimum of  $-0.16$ , maximum of  $0.16$  and the standard deviation of  $0.089$ . This indicates that the changes were in the normal range.

The relationships of the changed Insall-Salvati ratio and the changed Tegner-Lysholm scores showed no statistically significant relationships. This shows that the change of the Insall-Salvati ratio after surgery



**Fig. 1** Insall-Salvati ratio<sup>(12)</sup>

has no effect on the symptoms and the ability to use the knee joint ( $p = 0.122$ ). However, when considered only the Tegner-Lysholm scores before and after surgery solely, it is found that the relationship is statistically significant. This means that the after surgery scores are significantly higher than before surgery. And after the surgery, there are more patients in the good and excellent groups, a total of 86.77%. This indicates that at 6 months after surgery, the patients show the improved symptoms and the better use of the knee joint.

In terms of the limitations of the present study, the authors assumed that there may be errors in the measurement of the radiographic images. The reference point for measurement at tibial tubercle also may change after the operation. However, the authors tried to control this by determining the goniometer, measuring and recording the values manually. The exact positioning of the film was determined as well as the reporting of the essential values in ratio to reduce the potential impact arisen from the magnification of the radiographic.

## Conclusion

After the arthroscopic ACL reconstruction with patellar tendon graft, the Insall-Salvati ratio increased with no statistical significance. This increased change does not correlate with the symptoms and the ability to use the knee of the patients after surgery at 6 months as the patients who underwent surgical treatment show better symptoms and ability to use their knees.

## Potential conflicts of interest

None.

**Table 1.** The minimum, maximum, average and standard deviation values

		Min.	Max.	Mean	SD
Age (year)		20.00	34.00	24.09	3.44
Patellar tendon length (mm)	Preop.	41.00	60.00	48.68	5.41
	6 months	36.00	62.00	49.64	6.59
Insall-Salvati ratio	Preop.	0.84	1.15	1.02	0.10
	6 months	0.82	1.20	1.04	0.11
Tegner-Lysholm score	Preop.	52.00	87.00	71.14	10.66
	6 months	80.00	98.00	91.50	5.74

**Table 2.** The changes of the patellar tendon length, Insall-Salvati ratio, Tegner-Lysholm score in comparison of before surgery and at 6 months after surgery

		Min.	Max.	Mean	SD	Paired t-test
Patellar tendon length change	mm.	-6.00*	5.00	0.95	2.61	p = 0.101
	%	-14.29*	9.80	1.82	5.51	
Insall-Salvati ratio change	%	-0.16*	0.16	0.02	0.09	p = 0.218
Tegner-Lysholm score change		5.00	45.00	20.36	9.39	p = 0.00

\* The changes reduced

**Table 3.** Groups of patients (persons / percentage), according to the Tegner-Lysholm score

		<65	65-83	84-90	>90	p-value
Tegner-Lysholm score	Preop	6(27.27)	12(54.55)	4(18.18)	-	<0.001
	6 months	-	3(13.64)	3(13.64)	16(72.73)	

## References

- Breitfuss H, Frohlich R, Povacz P, Resch H, Wicker A. The tendon defect after anterior cruciate ligament reconstruction using the midthird patellar tendon—a problem for the patellofemoral joint? *Knee Surg Sports Traumatol Arthrosc* 1996; 3: 194-8.
- Mastrokalos DS, Springer J, Siebold R, Paessler HH. Donor site morbidity and return to the preinjury activity level after anterior cruciate ligament reconstruction using ipsilateral and contralateral patellar tendon autograft: a retrospective, nonrandomized study. *Am J Sports Med* 2005; 33: 85-93.
- Upadhyay N, Vollans SR, Seedhom BB, Soames RW. Effect of patellar tendon shortening on tracking of the patella. *Am J Sports Med* 2005; 33: 1565-74.
- Meisterling RC, Wadsworth T, Ardill R, Griffiths H, Lane-Larsen CL. Morphologic changes in the human patellar tendon after bone-tendon-bone anterior cruciate ligament reconstruction. *Clin Orthop Relat Res* 1993; 208-12.
- Dandy DJ, Desai SS. Patellar tendon length after anterior cruciate ligament reconstruction. *J Bone Joint Surg Br* 1994; 76: 198-9.
- Adam F, Pape D, Kohn D, Seil R. Length of the patellar tendon after anterior cruciate ligament reconstruction with patellar tendon autograft: a prospective clinical study using Roentgen stereometric analysis. *Arthroscopy* 2002; 18: 859-64.
- 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: 712-9.
8. Shaffer BS, Tibone JE. Patellar tendon length change after anterior cruciate ligament reconstruction using the midthird patellar tendon. *Am J Sports Med* 1993; 21: 449-54.
9. Shelbourne KD, Rubinstein RA Jr, Braeckel CJ, Butler JP. Assessment of patellar height after autogenous patellar tendon anterior cruciate ligament reconstruction. *Orthopedics* 1995; 18: 1073-7.
10. Krosser BI, Bonamo JJ, Sherman OH. Patellar tendon length after anterior cruciate ligament reconstruction. A prospective study. *Am J Knee Surg* 1996; 9: 158-60.
11. Insall J, Salvati E. Patella position in the normal knee joint. *Radiology* 1971; 101: 101-4.

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## การเปลี่ยนแปลงของ Insall-Salvati Ratio ภายหลังการผ่าตัดเอ็นไขว้หน้าหัวเข่าด้วยวิธีส่องกล้อง โดยใช้เอ็นสะบ้าหัวเข่า

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**วัตถุประสงค์:** มาตรฐานในการรักษาเอ็นไขว้หน้าเข่าคือการผ่าตัดทำเอ็นไขว้หน้าใหม่ เอ็นไขว้หน้าใหม่มักจะมาจากเอ็นในร่างกายของผู้ป่วย เอ็นสะบ้าหัวเข่าเป็นทางเลือกหนึ่งซึ่งได้รับความนิยม แต่บริเวณที่ถูกนำเอ็นไปเพื่อทำเอ็นใหม่ อาจเกิดภาวะแทรกซ้อนได้ เช่น การปวดหัวเข่าด้านหน้า หรือเอ็นสะบ้าเปลี่ยนแปลงความยาว ผู้นิพนธ์ศึกษาความเปลี่ยนแปลงของความยาวเอ็นสะบ้าหลังการผ่าตัดโดยใช้ Insall-Salvati ratio เป็นตัววัด

**วัสดุและวิธีการ:** ผู้นิพนธ์ศึกษาเข้าในผู้ป่วย 22 รายโดยได้รับการผ่าตัดทำเอ็นไขว้หน้าใหม่โดยศัลยแพทย์โรคกระดูกหนึ่งท่าน ทำการเก็บข้อมูลโดยการส่งภาพถ่ายรังสีหัวเข่าด้านข้าง, วัด Insall-Salvati ratio, และวัด Tegner Lysholm knee score ที่ก่อนผ่าตัด และหลังผ่าตัด 6 เดือน

**ผลการศึกษา:** ผู้นิพนธ์พบว่าหลังการผ่าตัด ความยาวของเอ็นสะบ้าเพิ่มขึ้น 0.95 มิลลิเมตร (ร้อยละ 1.82) ซึ่งไม่มีความสำคัญทางสถิติ ทางด้านของ Insall-Salvati ratio พบว่าเพิ่มขึ้นร้อยละ 2.75 ซึ่งไม่มีความสำคัญทางสถิติ สำหรับ Tegner Lysholm knee score พบว่ามีการเพิ่มขึ้น 20.36 คะแนน ซึ่งมีความสำคัญทางสถิติ

**สรุป:** ภายหลังการผ่าตัดเอ็นไขว้หน้า Insall-Salvati ratio จะมีการเปลี่ยนแปลงเพียงเล็กน้อย และผู้ป่วยทุกคนมีความพึงพอใจเมื่อติดตามผลการรักษา โดยไม่มีความสัมพันธ์กันระหว่าง Insall-Salvati ratio กับความพอใจหลังการผ่าตัด