

Evaluation of changes in the length and cross-sectional dimension of autogenous grafts from semitendinosus and gracilis tendons used for anterior cruciate ligament (ACL) reconstruction in patients with active growth plates: MRI analysis

Ocena zmian długości i wymiaru poprzecznego autogennego przeszczepu ze ścięgien mięśnia półścięgnistego i smukłego użytego do rekonstrukcji więzadła krzyżowego przedniego (ACL) u pacjentów z aktywnymi chrząstkami wzrostowymi: analiza MRI

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Abstract

Introduction. In recent years, there has been an increase in anterior cruciate ligament (ACL) injuries during childhood and adolescence.

Aim. The aim of this study is to observe the diameter and length of the graft change in the postoperative period.

Materials and methods. The study group consisted of 21 adolescents (11 boys and 10 girls) who underwent ACL reconstruction using hamstring and gracilis tendon grafts. MRI evaluations were performed at 3-6 and 24-26 months postoperatively to assess the width and length of the graft. The graft cross-sectional dimension was measured at the mid-substance of the tendons on sagittal scans in T1 and T2-weighted sequences. Length measurement was performed on axial ACL scans at its central portion (assessing mid-substance length). The collected measurements from both postoperative periods were compared and statistically analysed.

Results. MRI analysis conducted postoperatively showed a statistically significant decrease in graft cross-sectional dimension, from an average 7.21-5.82 mm. The intra-articular graft length measured in MRI at 3-6 months post-surgery averaged 21.52 mm, while the length measured at 24-26 months post-surgery averaged 22.42 mm.

Conclusions. Postoperative MRI analysis of reconstructed ACLs in adolescents with active growth plates demonstrated a reduction in graft cross-sectional dimension and a slight increase in graft length.

Key words: ACL reconstruction, paediatric population, MRI tendon graft evaluation.

Streszczenie

Wstęp. W ostatnich latach obserwuje się wzrost uszkodzeń więzadła krzyżowego przedniego w okresie dziecięcym i młodzieżowym.

Cel. Celem pracy jest zaobserwowanie czy średnica i długość przeszczepu zmienia się w okresie pooperacyjnym.

Materiał i metody. Grupę badaną stanowiło 21 nastolatków (11 chłopców i 10 dziewczynek), u których przeprowadzono rekonstrukcję ACL z przeszczepem ze ścięgien mięśnia półścięgnistego i smukłego. 3-6 oraz 24-26 miesięcy po zabiegu operacyjnym wykonano MRI w celu oceny średnicy i długości przeszczepu. Wymiar średnicy przeszczepu mierzono w środkowej, śródstawowej części ścięgna na skanach strzałkowych w sekwencjach T1 i T2 zależnych. Pomiar długości dokonano na skanach osiowych ACL w jego centralnej części (oceniono śródstawową długość). Zebrane wymiary z obu okresów pooperacyjnych porównano i zanalizowano statystycznie.

Wyniki. Analiza badań MRI, wykonana po rekonstrukcji, 21 kolan wykazała statystycznie istotne zmniejszenie wymiaru średnicy z średnio 7,21-5,82 mm. Długość wewnątrzstawowa przeszczepu w badaniu rezonansu magnetycznego wykonanego 3-6 miesięcy od operacji wyniosła średnio 21,52 mm. Pomiar długości więzadła po 24-26 miesiącach od operacji wyniósł średnio 22,42 mm.

Wnioski. Pooperacyjna analiza MRI zrekonstruowanych ACL u dzieci z aktywnymi chrząstkami wzrostowymi wykazała zmniejszenie średnicy oraz niewielkie wydłużenie przeszczepu.

Słowa kluczowe: rekonstrukcja ACL, populacja dziecięca, ocena przeszczepu ścięgnistego w MRI.

Introduction

The anterior cruciate ligament (ACL) plays a crucial role in the mechanics of the knee joint [1]. It provides stability in the frontal and sagittal planes and prevents excessive rotational movements of the knee joint. The quality of other anatomical elements of the joint, such as menisci and articular cartilage, depends on its integrity [2,3]. ACL is prone to the most common injuries associated with knee joint trauma [4,5,6] (Fig. 1). In recent years, there has been an increase in ACL injuries in paediatric and adolescent populations [7,8]. This may be attributed to early engagement in high-intensity sports such as skiing, soccer, handball, and others [8]. ACL reconstruction in paediatric patients is associated with good outcomes and a low rate of early and late complications [8]. The aim of this study is to observe the cross-sectional dimension and length of the graft change during the postoperative period.



Fig. 1. ACL injury visualized in MRI.

Materials and methods

Between 2018-2020 52 adolescents were treated for ACL injuries. Patients who did not exhibit active growth plates on MRI examination and those who experienced recurrent ligament injuries (2 cases) were excluded from the study. The study group comprised 21 adolescents (11 boys and 10 girls) who underwent ACL reconstruction using autogenous grafts from the semitendinosus and gracilis tendons (Tab. 1). All patients, during the postoperative period (6-9 months), showed no symptoms of secondary knee instability or other issues, as assessed using the KOOS scale. All subjects scored between 85-100 points on the KOOS scale. The mean age of the patients at the time of surgery was 13.1 years, with the youngest patient being 11 years and

Table 1. Study group with measurements of reconstructed ACL length and diameter.

| No | Age in years | Sex | 3-6 months after surgery | | 24-26 months after surgery | |
|----|--------------|-----|--------------------------|-------------|----------------------------|-------------|
| | | | diameter [mm] | length [mm] | diameter [mm] | length [mm] |
| 1 | 12 | M | 7 | 20 | 5.9 | 20 |
| 2 | 11 | F | 6.5 | 22 | 5 | 23 |
| 3 | 13 | M | 7.5 | 28 | 6.1 | 29 |
| 4 | 11 | F | 6.2 | 30 | 5.3 | 30 |
| 5 | 12 | M | 7.5 | 24 | 6 | 25 |
| 6 | 13 | M | 7.4 | 22 | 5.5 | 22 |
| 7 | 12 | M | 7.4 | 25 | 5.2 | 25 |
| 8 | 13 | F | 7.2 | 20 | 5.5 | 22 |
| 9 | 11 | F | 7 | 21 | 6 | 22 |
| 10 | 11 | F | 6.8 | 19 | 6 | 19 |
| 11 | 11 | F | 6.5 | 18 | 5.8 | 19 |
| 12 | 12 | M | 7.4 | 21 | 5.8 | 22 |
| 13 | 14 | M | 8.2 | 22 | 7.5 | 22 |
| 14 | 13 | F | 7.5 | 24 | 6 | 25 |
| 15 | 13 | M | 7.5 | 18 | 5.8 | 19 |
| 16 | 12 | F | 7 | 19 | 5.4 | 20 |
| 17 | 12 | M | 7.5 | 19 | 5.9 | 19 |
| 18 | 12 | F | 7 | 18 | 5.3 | 19 |
| 19 | 12 | F | 6.8 | 21 | 5.2 | 22 |
| 20 | 13 | M | 7.7 | 23 | 6.8 | 24 |
| 21 | 14 | M | 7.8 | 18 | 6.3 | 19 |

3 months old and the oldest being 14 years and 3 months old. MRI measurements of the graft's cross-sectional dimension and length were performed 3-6 months and 24-26 months after surgery. The cross-sectional dimension of the graft was measured in the middle of the tendon on sagittal scans in T1 and T2 sequences (Fig. 2).



Fig. 2. Measurement of reconstructed ACL width performed on sagittal MRI scan.

Length measurement was performed on axial scans of the ACL in its central part (evaluating mid-substance length) (Fig. 3). The MRI analysis was conducted by the same individual in all cases.

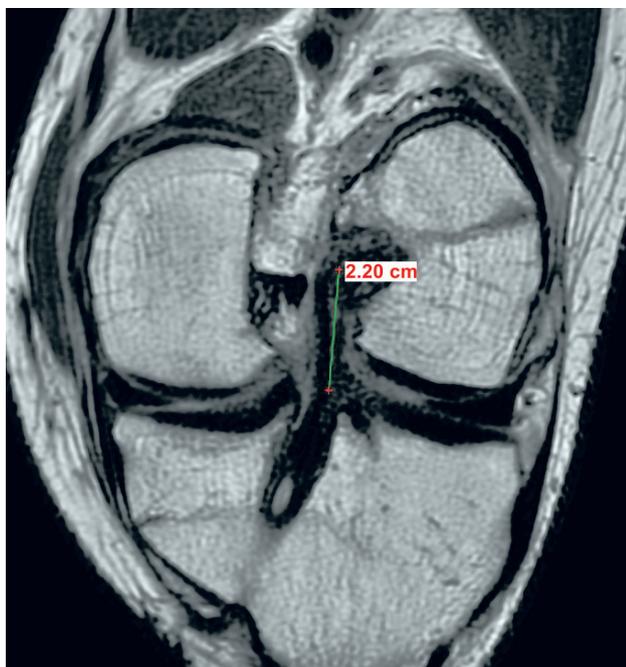


Fig. 3. Measurement of reconstructed ACL length performed on axial ACL scans in MRI

Surgical Technique

All patients underwent surgery using the same technique. Autogenous grafts from the semitendinosus and gracilis tendons were used for reconstruction. After preparing the tendon tissue, both ends of the tendons were sutured with non-absorbable sutures. The tendons were folded in half, resulting in an average graft length of 8.1 cm (range: 7.2-9.7 cm) and an average diameter of 7.2 mm (range: 5.5-8 mm). Under arthroscopic guidance, a tunnel was created starting at the typical insertion point of the ACL, passing through the distal growth plate of the femur, and ending on the lateral surface of the femoral condyle. A guide was used to drill a tunnel in the tibia, passing through the proximal growth plate and ending at the typical insertion point of the anterior cruciate ligament on the tibial plateau. The prepared tendons were passed through both tunnels from a medial to lateral direction. A titanium button was used to fix the graft on the femur, and a bioabsorbable interference screw with a length of 20 mm was used in the tibial canal. Statistical analysis of the cross-sectional dimension and length of the ACL graft at two postoperative time intervals was performed using the STATISTICA 13.0 software (StatSoft, Poland) and the Wilcoxon test.

Results

The analysis of MRI scans of 21 knees at 3-6 months after reconstruction showed an average cross-sectional dimension of the graft to be 7.21 mm (range: 6.2-8.2 mm). At 24-26 months after the operation, the cross-sectional dimension of the graft averaged 5.82 mm (range: 5-7.5 mm). Statistical analysis using the Wilcoxon test demonstrated a statistically significant decrease in the cross-sectional dimension ($p < 0.001$) in MRI performed at 3-6 months compared to the cross-sectional dimension at 24-26 months (Fig. 4). The intra-articular length of the graft measured by magnetic resonance imaging performed 3-6 months after surgery averaged 21.52 mm (range: 18-30 mm). The length measurement of the ligament 24-26 months after surgery averaged 22.42 mm (range: 19-30 mm). Statistical analysis revealed a statistically significant increase in intra-articular graft length ($p < 0.001$) (Fig. 4).

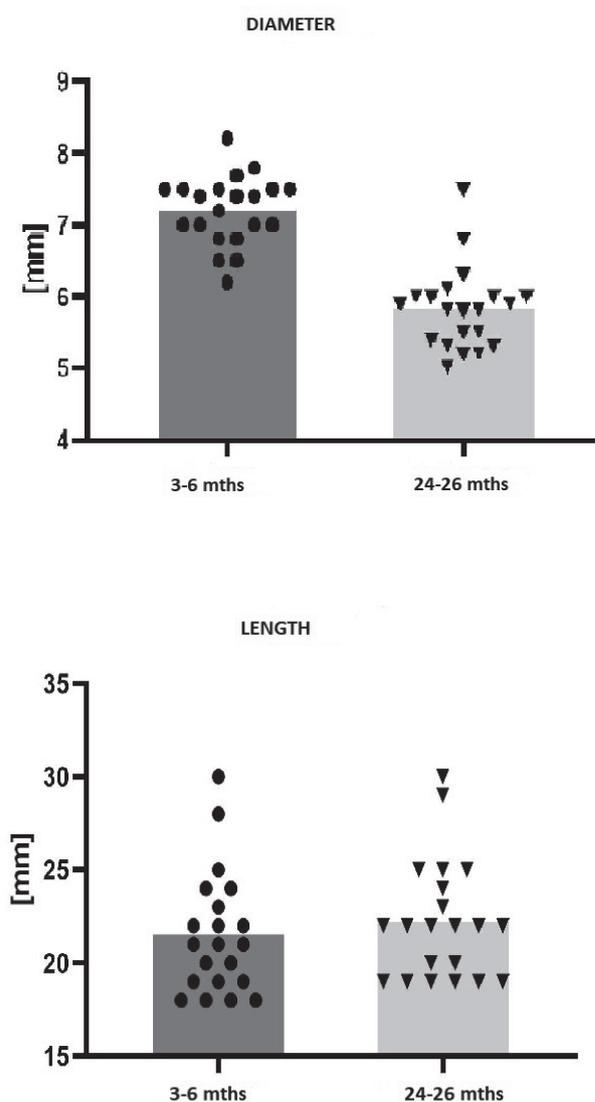


Fig. 4. Statistical analysis charts.

Discussion

There are few studies in the literature that consider the changes in the size of the anterior cruciate ligament (ACL) and the ACL graft from the semitendinosus and gracilis tendons in patients with active growth plates [10,11,12]. Despite the small sample size and a wide age range of patients, we attempted to evaluate this issue. A more detailed analysis would require dividing the patients into smaller age groups. The study may contain measurement errors during the assessment of MRI scans. Nevertheless, it appears that the observed changes in the size of the transplanted ACL in the paediatric population are significant and interesting, given the limited literature on this topic.

Putur et al. investigated changes in the physiological ACL of paediatric patients [9]. They noted a deceleration in ACL lengthening at the age of 11.5 years, with minimal subsequent growth, and complete cessation of growth at the age of 18. Similarly, the change in length observed in the transplanted ACL in our study in the 11-14-year-old population is significant but small, averaging 0.9 mm.

Mendez et al. demonstrated, based on the analysis of 21 patients, that the diameter of the autogenous ACL graft increased by an average of 2.2 mm with body growth [10]. In contrast, Astur et al., in a smaller study group, arrived at a different conclusion. In 10 patients, the diameter of the autogenous ACL decreased by 25% [11]. Bollen et al. assessed changes in the graft's dimension using MRI and found a significant lengthening of the graft beyond 18 months post-operatively in patients with particularly significant growth. Additionally, they observed no change in the diameter of the tendons [12]. Our study corroborates the findings of Astur and colleagues. In 21 patients, the cross-sectional dimension of the graft decreased by an average of 1.4 mm, representing approximately 20% of the initial size.

In another study, Astur et al. analysed the incidence of the need for repeat ACL reconstruction in three age groups. In children under 16 years of age, secondary ligament rupture occurred in 24.6% of cases. In comparison, individuals above 18 years of age had a reoperation rate of 9.2%, indicating a significantly higher rate of re-reconstructions [13].

The increased frequency of ACL re-injury may be associated with the observed reduction in graft dimension. Furthermore, the presence of an incompletely remodelled graft, as demonstrated by Pauvert et al., exhibits greater homogeneity in terms of the SNQ (Signal to Noise Quotient) and Howell scales 24 months after the graft compared to a physiological ACL [14].

Conclusion

Postoperative MRI analysis of reconstructed ACLs in children with active growth plates revealed a decrease in cross-sectional dimension and an increase in intra-articular graft length over time. Given the limited research in this area, further analysis is warranted.

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