Journal of ISAKOS xxx (xxxx) xxx

Contents lists available at ScienceDirect

Journal of ISAKOS

journal homepage: www.elsevier.com/locate/jisakos

Video Article

Anatomical hamstring tendons ACL reconstruction with the "linking rings" technique

Karl Eriksson, MD, PhD [a,b], Riccardo Cristiani, MD, PhD [c,d,*]

[a] Department of Orthopaedics, Stockholm South Hospital, Stockholm, Sweden
[b] Department of Clinical Science and Education, Karolinska Institute, Stockholm, Sweden
[c] Capio Artro Clinic, FIFA Medical Centre of Excellence, Sophiahemmet Hospital, Valhallavägen 91, 11486, Stockholm, Sweden
[d] Department of Molecular Medicine and Surgery, Stockholm Sports Trauma Research Center, Karolinska Institute, Stockholm, Sweden

ARTICLE INFO

Keywords:
ACL
Anterior cruciate ligament
Hamstring tendons

ABSTRACT

Hamstring tendons (HTs) are one of the most commonly used autografts for anterior cruciate ligament (ACL) reconstruction (ACLR). However, the tendon-to-bone healing of the HTs grafts within the bone tunnels has always been a concern. Periosteum contains pluripotent stem cells with osteogenic and chondrogenic potential which can allow a direct, stronger and faster healing of the HTs graft within the bone tunnels. In this technical note, we present a modification of anatomical ACLR with the semitendinosus tendon (ST) graft and periosteum augmentation using the "linking rings" technique. The ST is harvested together with periosteum from its distal insertion. An additional free periosteal flap is harvested from the proximal tibia, below the ST insertion. The two free ends of the ST are then linked with a strong non-resorbable suture forming a ring and then folded again creating a quadruple construct with two loops at each end. The periosteum is then wrapped and sutured around the quadruple ST graft on both sides of the linking rings near the femoral and tibial tunnel opening. A technical pearl is to use one artery clamp inside the double rings at the graft ends, pull apart simultaneously and equal the tension between the strands. Another technical pearl is to not pull the periosteum to obtain the flaps, but to use instead a periosteal elevator to preserve the cambium layer which contains the pluripotent stem cells.

Anatomical hamstring tendons ACL reconstruction with the "linking rings" technique

- The ST graft is harvested with periosteum from its distal insertion
- An additional free periosteal flap is harvested below the ST insertion with a 11-blade knife
- A periosteal elevator is used to harvest both periosteal flaps to preserve the cambium layer
- The free ends of the ST graft are sutured together creating a ring and then folded into a quadruple configuration. The periosteal flaps are wrapped and sutured with vicryl 2-0 on both sides of the graft (linking rings) near the femoral and tibial tunnel opening
- The cambium layer is faced outside to the bone tunnel
- If the diameter of the ST graft is less than 8 mm, the Gracilis tendon is also harvested and added to form a 6 or 7 stranded graft
- The centre of the femoral tunnel is placed predominantly in correspondence of the anteromedial bundle of the ACL
- The femoral tunnel is drilled with a steeper angle, creating an oval shaped tunnel entrance also covering a part of the posterolateral bundle
- The tibial tunnel is positioned at the centre of the tibial footprint of the ACL
- The graft is passed in the tunnels and fixed on both femur and tibia with a suspensory fixation device

* Corresponding author.
E-mail address: riccardo.cristiani87@gmail.com (R. Cristiani).

https://doi.org/10.1016/j.jisako.2022.07.001
Received 16 May 2022; Received in revised form 18 July 2022; Accepted 22 July 2022
Available online xxxx

Please cite this article as: Eriksson K, Cristiani R, Anatomical hamstring tendons ACL reconstruction with the "linking rings" technique, Journal of ISAKOS, https://doi.org/10.1016/j.jisako.2022.07.001

Technique structure

Outline of the clinical problem

Hamstring tendons are one of the most commonly used autografts for anterior cruciate ligament reconstruction (ACLR). Previous studies reported inferior donor site morbidity [1] and superior subjective knee outcomes [2] with Hamstring tendons (HTs) grafts compared with bone-patellar tendon-bone grafts. On the other hand, HTs grafts are associated with increased knee laxity after ACLR [2]. In a histological study, Eriksson et al. [3] showed that an HT graft can promote normal tendon-to-bone in growth through the formation of Sharpey's fibres and chondroid differentiation (direct healing). However, graft incorporation within the bone tunnels and the ligamentization process are slower with HTs grafts compared with bone-patellar tendon-bone grafts [4]. Osteointegration of HTs grafts within the bone tunnels can be enhanced with a periosteum autograft [5].

Treatment options

An ACL injury can be managed both conservatively and surgically. In patients involved in pivoting sports, early anatomical ACLR is indicated due to the risk of associated (cartilage and meniscus) injuries. For patients not involved in pivoting sports, a first line treatment with rehabilitation might be pursued. However, in case of persistent instability, anatomical ACLR is recommended [6].

Surgical indications and contraindications

Anatomical HTs ACLR with the "linking rings" technique can be performed routinely in any case of ACLR. There are no specific contraindications to this technique as there is no additional morbidity.

Outcomes of the technique

A prospective study by Chen et al. [7] evaluated 62 patients who underwent HTs ACLR with periosteum graft augmentation at a minimum 2-year follow-up. The median Lysholm knee score improved from 59 preoperatively to 94 postoperatively. Ninety-two percent of the patients had a normal or nearly normal International Knee Documentation Committee form(IKDC) postoperatively. Four (6%) patients had a grade 2 or greater anterior drawer test. One patient (2%) had a grade 3 pivot shift due to a graft rupture, and two patients (3%) had a grade 1 pivot shift. Bone tunnels enlargement of more than 1 mm was reported in 5% of the femoral tunnels and 6% of the tibial tunnels. In a case-series, Chen et al. [8] evaluated, at a mean 4.6-year follow-up, 312 patients who underwent HTs ACLR with periosteum graft augmentation. The median Lysholm knee score improved from 56 preoperatively to 95 postoperatively. Ninety-three percent of the patients had a normal or nearly normal IKDC postoperatively. Only 5.1% exhibited a grade 2 or greater anterior drawer test, and only 6.1% had a positive pivot shift. Bone tunnel enlargement of more than 1 mm was reported in 5.4% of femoral tunnels and 6.1% of tibial tunnels.

In a prospective randomised study, Robert et al. [9] showed that the use of a periosteal flap in HTs ACLR significantly reduced enlargement of the femoral tunnel opening. Similar findings were reported by Sun et al. [10]. The authors compared 52 patients who underwent HTs ACLR with periosteum graft augmentation (experimental group) with 58 patients who underwent HTs ACLR without periosteum graft augmentation (control group). The mean postoperative follow-up was 19 (12–25) months. The authors found a better postoperative side-to-side laxity measured with the KT-1000 (134-N) arthrometer in the experimental group compared with the control group (1.7 ± 1.1 mm vs. 2.3 ± 1.0 mm). The average enlargement of both the femoral (17.3% vs. 34.5%) and tibial (19.2 vs. 36.2%) tunnel was less in the experimental group compared with the control group.

Complications

No specific complications are related to this technique. The addition of a periostal flap to HTs graft as healing enhancement procedure carries no additional morbidity.

Conclusion and future perspectives

A periosteum autograft may enhance osteointegration of HTs grafts within the bone tunnels, allowing for a stronger and faster healing. Anatomical HTs ACLR with the "linking rings" technique can be safely performed in any case of ACLR, without any additional morbidity. Autogenous periosteum is readily available from the proximal tibia and can be easily harvested from the same incision used for HTs harvesting.

Future studies are required to determine if the application of periosteum augmentation to HTs grafts in ACLR can lead to superior clinical outcomes.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: Karl Eriksson reports a relationship with Arthrex Inc that includes: consulting or advisory.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jisako.2022.07.001.

References

[1] Xie X, Liu X, Chen Z, Yu Y, Peng S, Li Q. A meta-analysis of bone-patellar tendon-bone autograft versus four-strand hamstring tendon autograft for anterior cruciate ligament reconstruction. Knee 2015 Mar;22(2):100–10. https://doi.org/10.1016/j.knee.2014.11.014.

[2] Cristiani R, Sarakatsianos V, Engström B, Samuelsson K, Forssblad M, Stålman A. Increased knee laxity with hamstring tendon autograft compared to patellar tendon autograft: a cohort study of 5462 patients with primary anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc 2019 Feb;27(2):381–8. https://doi.org/10.1007/s00167-018-5029-9.

[3] Eriksson K, Kindblom LG, Wredmark T. Semitendinosus tendon graft ingrowth in tibial tunnel following ACL reconstruction: a histological study of 2 patients with different types of early graft failure. Acta Orthop Scand 2000 Jun;71(3):275–9. https://doi.org/10.1080/000164700317411870.

[4] Ekdahl M, Wang JH, Ronga M, Fu FH. Graft healing in anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc 2008 Oct;16(10):935–47. https://doi.org/10.1007/s00167-008-0584-0.

[5] Kuang GM, Yau WP, Lu WW, Chiu KY. Osteointegration of soft tissue grafts within the bone tunnels in anterior cruciate ligament reconstruction can be enhanced. Knee Surg Sports Traumatol Arthrosc 2010 Aug;18(8):1038–51. https://doi.org/10.1007/s00167-009-0910-1.

[6] Diermeier T, Rothrauff BB, Engebretsen L, et al., Panther Symposium ACL Treatment Consensus Group. Treatment after anterior cruciate ligament injury: panther symposium ACL treatment consensus group. Knee Surg Sports Traumatol Arthrosc 2020 Aug;28(8):2390–402. https://doi.org/10.1007/s00167-020-06012-6.

[7] Chen CH, Chen WJ, Shih CH, Chou SW. Arthroscopic anterior cruciate ligament reconstruction with periosteum-enveloping hamstring tendon graft. Knee Surg Sports Traumatol Arthrosc 2004 Sep;12(5):398–405. https://doi.org/10.1007/s00167-004-0498-4.

[8] Chen CH, Chang CH, Su CI, et al. Arthroscopic single-bundle anterior cruciate ligament reconstruction with periosteum-enveloping hamstring tendon graft: clinical outcome at 2 to 7 years. Arthroscopy 2010 Jul;26(7):907–17. https://doi.org/10.1016/j.arthro.2009.11.011.

[9] Robert H, Es-Sayeh J. The role of periosteal flap in the prevention of femoral widening in anterior cruciate ligament reconstruction using hamstring tendons. Knee Surg Sports Traumatol Arthrosc 2004 Jan;12(1):30–5. https://doi.org/10.1007/s00167-003-0380-9.

[10] Sun R, Chen BC, Zhang XY, et al. Anterior cruciate ligament reconstruction using periosteum wrapped autologous hamstring tendons: clinical research. Zhonghua Yi Xue Za Zhi 2010 Jan 19;90(3):182–6. PMID: 20356554.