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Original article

Anterior Cruciate Ligament Reconstruction: A 2015 global perspective of the Magellan Society

Yee Han Dave Lee [a,*], Ryosuke Kuroda [b], Kai Ming Chan [c]

[a] *Department of Orthopedic Surgery, Changi General Hospital, Singapore*
[b] *Department of Orthopedic Surgery, Kobe University Graduate School of Medicine, Kobe, Japan*
[c] *Department of Orthopedics and Traumatology, The Chinese University of Hong Kong, Hong Kong SAR, China*

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Abstract

Background/objective: The Magellan Society is composed of > 150 high-volume fellowship-trained sports surgeons from four continents. These surgeons represent their regional sports organisations in travelling fellowships and are considered to be opinion leaders in their respective organisations. Prior to the 2014 Magellan Meeting in Arima, Japan, a survey was conducted to understand how Magellan members perform anterior cruciate ligament (ACL) reconstruction. This study aims to better understand how ACL reconstruction is performed by sports surgeons worldwide and to determine differences in surgical practice.
Methods: A survey was conducted prior to the Magellan Meeting in Arima, Japan. Information on ACL graft of choice for primary surgery and revision surgery, preferred surgical techniques, and femoral and tibial graft fixation methods was collected. The incidence of meniscal tears and the management of injuries in ACL surgery were also studied. The results of the survey are discussed in this article.
Results: A response rate of 51% (72 member respondents) was achieved for this survey. Hamstring autograft (58%) was the graft of choice for primary ACL reconstruction. The next most common autograft used was bone patella tendon bone autograft (28%). Allograft was the graft of choice in only 4% of respondents. The region of origin of surgeons and the age of surgeons were factors in the ACL graft of choice. Seventy-five percent of surgeons practised single-bundle ACL reconstructions only, 22% performed both single-bundle and double-bundle ACL reconstructions, and 3% performed double-bundle ACL reconstructions exclusively. Sixty-two percent of the respondents drilled femoral tunnels using the anteromedial portal technique. Meniscus repairs were performed in 25% of ACL reconstructions, on average.
Conclusion: Based on the survey, hamstring transportal anatomic single-bundle ACL reconstruction with meniscus preservation is the preferred ACL reconstruction technique of high-volume fellowship-trained sports surgeons.

Keywords: ACL; anatomic reconstruction; survey

Introduction

Practitioners' understanding of anterior cruciate ligament (ACL) anatomy and knee kinematics has made anatomic ACL reconstruction the standard of care among sports knee surgeons. The Magellan Society, a group of > 150 sports surgeons from four continents (North America, Europe, Asia Pacific, and South America), organised a biannual meeting in Arima, Japan, in April 2014. All surgeons in this group were members of the American Orthopedic Society for Sports Medicine; the European Society for Sports Traumatology, Knee Surgery, and Arthoscopy; the Asia-Pacific Knee, Arthroscopy and Sports Medicine Society; and the Latin American Society of Knee Arthroscopy and Sports Medicine who have participated in cross-continent travelling fellowships between member organisations.

* Corresponding author. Changi General Hospital, 2 Simei Street 3, 529889, Singapore.
E-mail address: Dave_Lee@cgh.com.sg (Y.H.D. Lee).

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We prepared a questionnaire to "poll" the opinions of Magellan members on the current practice of ACL surgery to facilitate a discussion of the current state of ACL reconstruction during the meeting. This survey allowed the sports surgeons to share their experiences and to contrast practice behaviours in different regions. The findings from this survey and the discussions in the meeting are presented in this article.

Materials and methods

A survey form was sent out to all 150 surgeons through the Magellan Society Secretariat. The questions dealt with ACL graft of choice, surgical technique, graft fixation, revision ACL graft of choice, rehabilitation protocol after surgery, percentage of concomitant meniscal injuries, and percentage of meniscus repairs.

The questions included the following. (1) Primary ACL graft of choice: (i). autograft (hamstring, bone patella tendon bone [BTB], and quadriceps tendon) and (b) allograft. (2) ACL surgical technique: (i) single-bundle ACL reconstruction, (ii) double-bundle ACL reconstruction, and (iii) both single-bundle and double-bundle ACL reconstructions. (3) ACL femoral tunnel drilling method: (i) anteromedial portal, (ii) transtibial, and (iii) outside-in. (4) ACL graft fixation method: (i) femoral fixation and (ii) tibial fixation. (5) Use of ACL backup tibial fixation. (6) Revision ACL graft of choice. (7) Rehabilitation time frame after ACL reconstruction: (i) when patients were allowed jogging, (ii) when patients were allowed side-to-side training, and (iii) when patients were allowed to return to competition. (8) Percentage of meniscal injuries and meniscus repairs performed in ACL reconstruction. (9) Percentage of bucket-handle meniscal tears repaired.

We collated the survey results and summarised them in the figures and tables. Test of significance was performed on various variables using Fisher's exact test.

Seventy-two replies were received, representing a 51% response rate. The breakdown of survey respondents by continent was as follows: North America (American Orthopedic Society for Sports Medicine), $n = 30$; Europe (European Society for Sports Traumatology, Knee Surgery, and Arthroscopy), $n = 24$; Asia Pacific (Asia-Pacific Knee, Arthroscopy, and Sports Medicine Society), $n = 15$; and South America (Latin American Society of Knee Arthroscopy and Sports Medicine), $n = 3$.

Figure 1 presents the regions of origin of the respondents. The replies came from the United States, Canada, Germany, Switzerland, United Kingdom, Italy, France, Austria, Belgium, Greece, Croatia, Spain, Australia, New Zealand, China, Hong Kong, Japan, Taiwan, Singapore, Philippines, Chile, and Argentina.

The mean age of survey respondents was 51 years (range, 36–72 years). The mean number of ACL reconstruction cases performed per year was 130 (range, 20–400), and the mean number of revision ACL cases performed per year was 22 (range, 3–80).

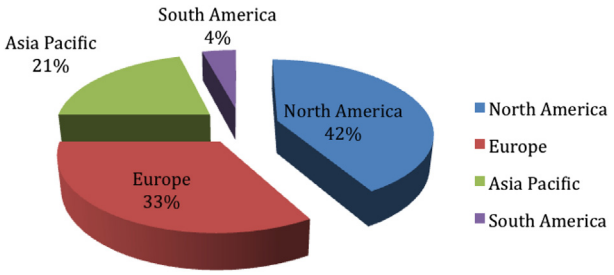

Figure 1. Survey respondents by region of origin.

Results

Primary ACL graft of choice

Hamstring autograft was the most common graft of choice amongst the respondents [42 surgeons (58.3%)], whereas BTB autograft was the second most common (20 surgeons). Allograft was the graft of choice for primary ACL reconstruction in only 4% (3 surgeons) of the respondents. Figure 2 presents the primary ACL grafts of choice of the respondents.

Surgeons' region of practice influenced their graft of choice. The graft of choice among surgeons in Asia Pacific was hamstring autograft. Figure 3 presents the ACL grafts of choice by region.

Younger surgeons (<50 years) worldwide were more likely to indicate hamstring autograft as their ACL graft of choice ($p = 0.01$). The younger North American surgeons (<50 years) preferred hamstring autograft, but this trend did not reach statistical significance. The younger European surgeons were more likely to use hamstring autograft than BTB autograft as ACL graft ($p = 0.024$).

Revision ACL graft of choice

Revision ACL graft of choice was strongly dependent on the first graft. Patients who had hamstring ACL reconstruction would most likely have BTB autograft as the revision ACL graft of choice, and vice versa.

Eighty-two percent of surgeons preferred autograft for revision ACL surgery. Twelve surgeons (18%) indicated allograft tissue as their graft of choice for revision ACL surgery. Figure 4 presents this breakdown.

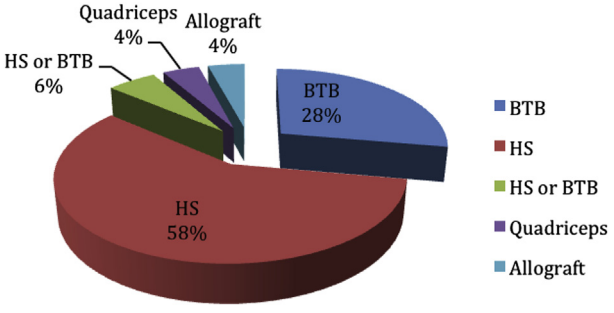

Figure 2. Graft of choice for primary anterior cruciate ligament reconstruction. BTB = bone patella tendon bone; HS = hamstring.

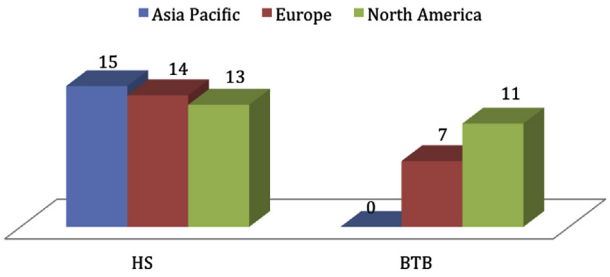

Figure 3. Anterior cruciate ligament (ACL) graft of choice by region.

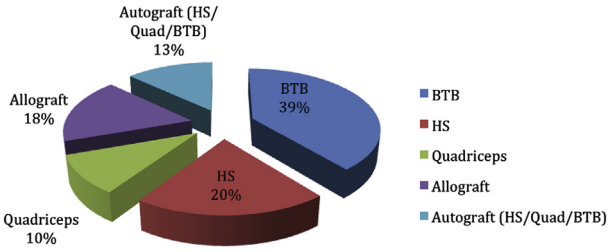

Figure 4. Revision ACL graft of choice. ACL = anterior cruciate ligament; BTB = bone patella tendon bone; HS = hamstring; Quad = quadriceps.

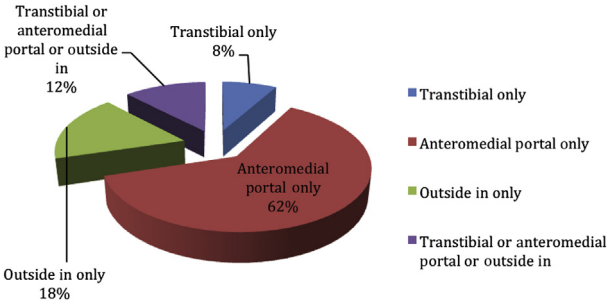

Figure 6. Anterior cruciate ligament (ACL) femoral tunnel drilling.

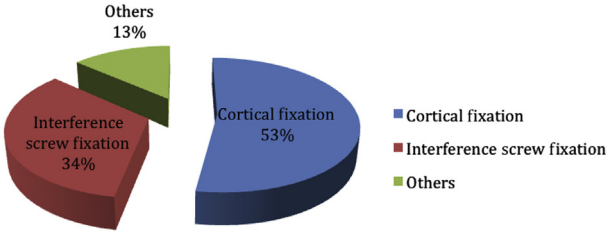

Figure 7. Anterior cruciate ligament femoral fixation.

Primary ACL surgical technique

Most surgeons [54 (75%)] performed single-bundle ACL reconstructions. Sixteen surgeons (22.2%) practised both single- and double-bundle ACL reconstructions. Only two surgeons (2.8%) practised double-bundle ACL reconstruction in all their cases. Figure 5 presents surgeons' choices for ACL reconstruction.

Most surgeons [46 (63.9%)] used the anteromedial portal technique for femoral tunnel drilling, six surgeons (8.3%) drilled femoral tunnels through tibial tunnels (transtibial), and 13 surgeons (13.9%) used outside-in femoral tunnel drilling. The remaining 13 surgeons (13.95%) used a variety of femoral tunnel drilling methods. Figure 6 presents the femoral tunnel drilling techniques practised.

ACL graft fixation

Thirty-nine surgeons (53%) used cortical femoral fixation. Twenty-five surgeons (34%) used interference screws in femoral fixation (Figure 7). The choice of fixation was dependent on the graft type used. Surgeons who used soft-tissue autografts usually used femoral cortical fixation. Conversely, surgeons who used BTB autografts usually used interference screws in femoral fixation. However, six surgeons (8.3%) used soft-tissue autografts (hamstring and quadriceps tendon) with femoral interference fixation, whereas three surgeons (4.2%) used cortical femoral fixation with BTB autografts.

Fifty-three surgeons (86%) used interference screws in tibial fixation. Thirteen percent of respondents practised backup tibial fixation.

Meniscus repairs

Meniscus repair was performed in conjunction with ACL reconstruction in 25% of cases (range, 5–60%), on average. Some surgeons found a need to repair the meniscus in > 50% of ACL reconstruction cases. Seventy-eight percent of the respondents would attempt to repair bucket-handle meniscal tears (Figure 8).

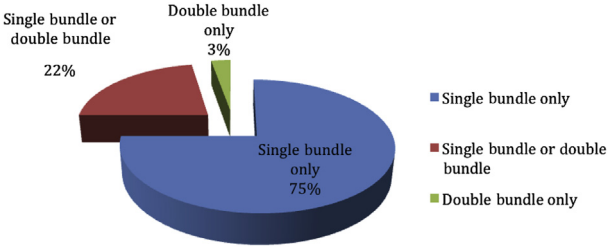

Figure 5. Primary anterior cruciate ligament (ACL) surgical technique: single-bundle or double-bundle.

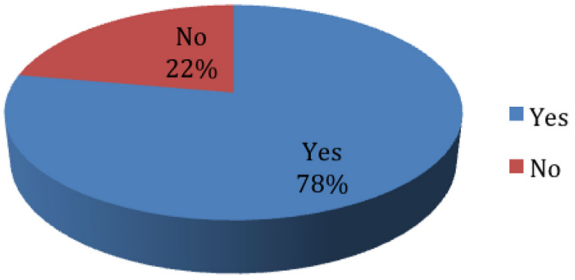

Figure 8. Percentage of surgeons who would or would not attempt to repair concomitant bucket-handle meniscal tears during anterior cruciate ligament reconstruction.

Table 1
Rehabilitation time frames after anterior cruciate ligament reconstruction.

Activity	Time (mean)	Time (range)
Jogging (wk)	13	6–26
Training side to side (mo)	5.5	2–8
Return to play (mo)	8.6	3–12

Rehabilitation

Most surgeons allowed jogging at an average of 13 weeks (range, 6–26 weeks). They allowed side-to-side training at an average of 5.5 months (range, 2–8 months). The mean time to return to full competition was 8.6 months (range, 3–12 months). Table 1 summarises the rehabilitation time frames of the respondents.

A comparison of the time the patients were allowed to perform these milestones between surgeons who used hamstring autograft and surgeons who used BTB autograft revealed that there was no difference in time frame.[8,9] Table 2 presents rehabilitation time frames by ACL graft type.

Discussion

This survey presents a cross-sectional view of the state of ACL reconstruction performed by sports surgeons worldwide. Other similar surveys have been performed within a country or region, but few have such international representation.[1–9] In addition, this survey includes a high proportion of high-volume fellowship-trained sports surgeons who are key opinion leaders in their respective regional sports organisations. As such, this survey provides a current representation of how ACL injury is managed in each continent.

ACL graft of choice

Many previous surveys have shown that BTB autograft is more prevalent in North America. Two surveys have shown that BTB autograft is preferred to hamstring autograft[1–7] by professional basketball and football athletes in North America. Similar to our findings, more recent surveys have shown that hamstring autograft is the current graft of choice worldwide.[4,10,11]

In our study, North American respondents, especially those older than 50 years, preferred BTB autografts. We also found that European surgeons younger than 50 years preferred hamstring autograft as their primary ACL graft of choice. Unlike other studies, we have shown that the trend in the graft of choice is related to the age of surgeons.

Table 2
Rehabilitation time frames for bone patella tendon bone versus hamstring anterior cruciate ligament reconstructions.

	Jogging (wk)	Training side to side (mo)	Return to play (mo)
Bone patella tendon bone	13	4.9	8.2
Hamstring	12.4	5.7	8.9

Ten years ago, we saw an increase in the use of allograft tissue in ACL surgery.[1–6] This trend has recently reversed, as seen in the more recent ACL surveys by Magnussen et al[6] and Middleton et al.[10] This is perhaps influenced by public perception, as reflected in a recent study by Matava et al,[12] who surveyed 210 individuals in North America regarding their perception of ACL reconstruction; more than half (56%) preferred autograft ACL reconstruction. Allograft tissue is also not readily available in many Asian and European countries and is only permitted for use when all other autograft sources had been exhausted.

Some early studies highlighted concerns with the use of allograft tissue in ACL reconstruction.[13,14] The subsequent 5- and 10-year clinical follow ups showed that allograft ACL reconstruction had clinical outcomes comparable to those of autograft reconstruction.[15–17] However, a recent study by Pallis et al[18] showed that a young active cohort who received allograft tissue for ACL reconstruction were significantly more likely than those who underwent autologous reconstruction to experience clinical failure requiring revision reconstruction.

Our survey showed that only 4% of surgeons used allografts in primary ACL reconstruction. In comparison to Barker et al,[1] who conducted a survey of North American surgeons where 43% of respondents used allograft tissue in primary ACL reconstruction, our group polled a larger international group of surgeons who preferred autograft tissue for primary ACL reconstruction.

Revision ACL

Most surgeons (82%) preferred autograft tissue for revision ACL surgery. This finding is in contrast to that of the Mars Group, which found that > 50% of revision ACL reconstructions were performed with allograft tissue.[19] In a recent study by Mall et al,[20] 43% of the surgeons surveyed indicated that they would use autograft tissue for revision ACL surgery. This is supported by the fact that many surgeons in our cohort are comfortable in using various sources of autograft for ACL reconstruction, which allows them to switch to another autograft option in a revision ACL scenario.

ACL technique

In the past decade, there has been a trend towards double-bundle ACL reconstruction amongst sports surgeons.[21,22] A cadaveric study showed that double-bundle ACL reconstruction restored normal patellofemoral contact pressure,[23] tibiofemoral joint pressure,[24] rotational stability,[25] anterior–posterior and medial–lateral laxities,[26] and intact knee kinematics[21–25] better than did other techniques. Anatomic ACL reconstruction is defined as the functional restoration of the ACL to its native dimensions, collagen orientation, and insertion sites.[27,28]

The first meta-analysis that compared single-bundle versus double-bundle ACL reconstructions in randomised controlled trials concluded that there were no significant differences in pivot-shift testing.[29] A recent meta-analysis by Björnsson

et al[30] and Mascarenhas et al[31] showed benefits with double-bundle ACL reconstruction. Björnsson et al[30] found that, based on current evidence, double-bundle reconstructions have fewer reruptures and less laxity; however, they found no difference between patient-reported outcomes and objective findings. Mascarenhas et al[31] concluded that double-bundle ACL reconstruction provides better postoperative knee stability than does single-bundle ACL reconstruction but that their clinical outcomes and risk of graft failures are similar.

We found that most respondents (75%) practised single-bundle reconstruction. A smaller percentage of respondents performed both single- and double-bundle ACL reconstructions. Only a small proportion of the respondents practised double-bundle reconstruction exclusively. This is in line with a recently published study by Mall et al[8] where 22 of the 25 surgeons (88%) surveyed practised anatomic ACL reconstruction.

Femoral tunnel drilling

Because our cohort was composed of high-volume ACL surgeons, most respondents were conversant on the different femoral tunnel drilling techniques. Consistent with worldwide trends, most [46 of 72 (64%)] of the surgeons surveyed drilled femoral tunnels using the anteromedial portal technique. In their recent survey of surgeons treating National Football League and National Collegiate Athletic Association football players, Erickson et al[9] reported that 67% of the surgeons drilled femoral tunnels using the anteromedial portal technique, whereas 2% used transtibial femoral tunnel drilling. Thus, surgeons who perform high-volume ACL reconstruction prefer the anteromedial portal technique for femoral tunnel preparation.

Transtibial femoral tunnel drilling has many drawbacks. In a cadaveric study, Bedi et al[32] found that a femoral tunnel drilled transtibially was anterior and superior to the femoral footprint. They concluded that independent anteromedial portal drilling allows for accurate positioning at the centre of the native footprint.[32] Outside-in femoral tunnel drilling was practised by 13 (18%) of the surgeons surveyed. This technique allows for independent drilling of femur and tibial tunnels in ACL reconstruction.[33] The benefits of outside-in drilling include safety of lateral knee structures, less risk of posterior wall blowout, and longer femoral tunnel for graft fixation.[34,35]

It is necessary to appreciate that the technique used in femoral tunnel drilling is less important than the need for anatomic ACL reconstruction. Many experienced surgeons are able to attain an anatomic femoral tunnel position. However, among younger surgeons, drilling the femoral tunnel using the anteromedial portal technique is perhaps the most reliable means to achieve an anatomic femoral tunnel position.

Graft fixation

In our survey, the type of graft fixation used was dependent on the graft used. For BTB autografts, interference screws were most commonly used for femoral fixation. Cortical femoral fixation was the most common method used to fix soft-tissue grafts. Some surgeons practised femoral soft-tissue graft fixation with interference screws because they subscribed to the concept of joint line fixation. The proposed benefits of soft-tissue graft fixation with interference screws are reduced graft "working length" and improved stiffness, which translates into decreased knee laxity. Soft-tissue graft fixation with interference screws also reportedly improves graft healing at the tunnel aperture in an animal model, as proposed by Weiler at al.[35]

In a porcine biomechanical study, Ahmad et al[36] found that suspensory cortical femoral fixation had higher ultimate failure load and less graft slippage than interference screws. Milano et al[37] and Miller et al[38] also showed that extracortical fixation has a mean load to failure of 700–1150 N. The failure load for interference screws in soft-tissue grafts is close to 450 N, which was termed by Noyes et al[39] as the physiological load that the knee has to withstand.

We observed a preference for bioabsorbable interference screws for tibial fixation. Some authors[40–42] reported that metal screws, compared with bioabsorbable screws, had higher rates of graft laceration in hamstring ACL reconstruction. A meta-analysis that compared ACL reconstruction outcomes between bioabsorbable and metallic screws found no significant differences in functional outcomes or stability.[43]

In addition, 13% of the surgeons surveyed used supplementary tibial fixation such as soft-tissue staples. In their biomechanical study of a porcine model, Walsh et al[44] found that soft-tissue grafts fixed with retroscrews backed up with suture buttons had higher ultimate failure loads and stiffer constructs that grafts fixed with either retroscrews or suture buttons alone. Hill et al,[45] in their randomised controlled study, found that supplementary tibial staple fixation in female patients undergoing hamstring autograft ACL reconstruction with interference screws for tibial fixation can reduce knee laxity at 2 years compared with interference screws for tibial fixation alone. These studies suggested benefits for backup tibial fixation in selected patients.

Meniscal injury associated with ACL injury

A high incidence of meniscal injuries has been associated with ACL injuries. In this age of meniscus preservation, our group needed to perform meniscus repair in 25% of ACL reconstruction cases, on average. Some surgeons needed to repair the meniscus in > 50% of ACL reconstructions. Similarly, 78% of surgeons in our cohort would attempt to repair bucket-handle meniscal tears to preserve the meniscus.

Few other surveys have highlighted the incidence of meniscus repairs in ACL reconstructions. In a cohort of high-volume sports surgeons, the meniscus is recognised to be of utmost importance for future joint preservation and ACL graft protection. Spang et al[46] showed in their cadaveric biomechanical study that the meniscus is a secondary stabiliser of the ACL and that meniscectomy produces an increased strain on ACL graft. Thus, preserving the meniscus in ACL surgery

helps to protect the graft from subsequent failure. The literature has shown that meniscus-deficient knees are exposed to increased articular contact pressures and typically progress to joint degeneration.[47−49] In their meta-analysis of the effects of meniscus on ACL outcomes at > 2 years of follow up, Magnussen et al[50] found that all patients who underwent partial meniscectomy developed radiographic changes. In their 24-year follow up of patients who underwent ACL reconstruction, Pernin et al[51] highlighted the importance of meniscus preservation in preventing osteoarthritis. They found that only 38% of patients with intact medial meniscus, compared with 68% of patients who had undergone meniscectomy, developed osteoarthritis.

Rehabilitation

Erickson et al,[9] in their recent survey of National Football League and National Collegiate Athletic Association surgeons, reported that 55.8% of the respondents recommend waiting for at least 6 months whereas 12.3% recommend waiting for at least 9 months. None of the respondents recommend waiting for > 12 months. In our survey, we found that most surgeons allowed return to sports at an average of 8.6 months, which is slightly longer than that found by Erickson et al.[9] This can be explained by the epidemiology of the patients, as the study of Erickson et al[9] used professional athletes as their patient cohort. We postulate that our survey respondents prioritise sufficient time for graft integration before allowing their patients to return to high levels of activity.

Conclusion

Our survey shows that hamstring transportal anatomic single-bundle ACL reconstruction with meniscus preservation is the preferred ACL reconstruction technique of high-volume fellowship-trained sports surgeons worldwide.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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