New Trends in Anterior Cruciate Ligament Reconstruction: A Systematic Review of National Surveys of the Last 5 Years

Alberto Grassi[1] Christian Carulli[2] Matteo Innocenti[2] Massimiliano Mosca[1] Stefano Zaffagnini[1] Corrado Bait[3] SIGASCOT Arthroscopy Committee

[1] II Clinica Ortopedica e Traumatologica, IRCSS Istituto Ortopedico Rizzoli, Bologna, Italy
[2] Orthopaedic Clinic, Department of Surgery and Translational Medicine, University of Florence, Florence, Italy
[3] Joint Surgery and Sport Medicine Unit, Istituto Clinico Villa Aprica, Como, Italy

Address for correspondence Alberto Grassi, MD, II Clinica Ortopedica e Traumatologica, IRCSS Istituto Ortopedico Rizzoli, Via Pupilli 1, Bologna 40136, Italy (e-mail: alberto.grassi3@studio.unibo.it).

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Abstract

The purpose of this study was to analyze national surveys of orthopaedic surgeons on anterior cruciate ligament (ACL) reconstruction to determine their preferences related to the preferred graft, femoral tunnel positioning, fixation and tensioning methods, antibiotic and anti-thromboembolic prophylaxis, and use of tourniquet and drains. A systematic search of PubMed, Web of Science, and Cochrane Library was performed. Inclusion criteria were surveys of ACL reconstruction trends and preferences published in the past 5 years (2011–2016), involving members of national societies of orthopaedics. Information regarding survey modalities, population surveyed, graft choice both in the general or in the athletic population, surgical technique, fixation, use of antibiotic, tourniquet, drains, and anti-thromboembolic prophylaxis was extracted. Eight national surveys were included from Europe (three), North or Latin America (three), and Asia (two). Overall, 7,420 questionnaires were sent, and 1,495 participants completed the survey (response rate ranging from 16 to 76.6%). All surveys reported the hamstring tendon (HT) autograft as the preferred graft, ranging from 45 to 89% of the surveyed population, followed by bone-patellar tendon-bone (BPTB) graft (2–41%) and allograft (2–17%). Only two surveys focusing on graft choice in athletic population underlined how in high-demand sportive population the graft choices changes in favor of BPTB. Single-bundle reconstruction was the preferred surgical technique in the four surveys that investigated this issue. Five surveys were in favor of anteromedial (AM) portal and two in favor of trans-tibial technique. Suspension devices for femoral fixation were the preferred choice in all but one survey, while interference screws were the preferred method for tibial fixation. The two surveys that investigated graft tensioning were in favor of manual tensioning. The use of tourniquet, antibiotics, drains, and anti-thromboembolic prophylaxis were vaguely reported. A trend toward the preference of HT autograft was registered in all the surveys; however, sport participation has been highlighted as an important variable for increased use of BPTB. Single-bundle reconstruction with AM portal technique and suspension femoral

Keywords
- anterior cruciate ligament
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fixation and screws fixation for the tibia seem the preferred solution. Other variables such as tensioning, antibiotic, anti-thromboembolic prophylaxis, tourniquet use, and drains were investigated scarcely among the surveys; therefore, no clear trends could be delineated. This is a Level V, systematic review of expert opinion study.

Introduction

Anterior cruciate ligament (ACL) reconstruction is a successful procedure independently by the choice of graft, surgical technique, and fixation devices.[1] Nevertheless, to date there is no consensus about the gold standard method for ACL reconstruction. Even if recent clinical evidence showed that both hamstring tendons (HT) and bone-patellar tendon-bone (BPTB) have advantages and drawbacks, there is still not an ideal graft reported in literature.[2–4] Similarly, several methods of femoral and tibial tunnel placement have been proposed during the last decades, with no clear superiority of one technique on another.[5–10] Finally, many metallic and soft absorbable and non-absorbable fixation devices have been released in the market over the years, showing comparable clinical outcomes.[11,12]

Several surveys have been recently performed with the aim to delineate national trends on the above-mentioned topics, as proper indications and precise surgical techniques are crucial to achieve a postoperative stability and a full return to sports activity. Although every surgeon plans his work based on experience and scientific evidence, we believe strongly important is the analysis of surveys to show the trends and to guide the choices of those surgeons who want to start performing this specific surgical procedure.

The purpose of the present study was to analyze national surveys of orthopaedic surgeons on ACL reconstruction to determine the surgical experience of participants to the surveys and their preferences related to the preferred graft, femoral tunnel positioning, fixation and tensioning methods, antibiotic and anti-thromboembolic prophylaxis, and use of drains.

The hypothesis of the study was that there are no differences in the choice of graft, surgical techniques, and fixation devices used for ACL reconstruction according to the selected national surveys.

Methods

As an initiative of the members of the Arthroscopy Committee of the Italian Society of Knee, Arthroscopy, Sport, Cartilage and Orthopaedic Technologies (SIGASCOT), the study design of this systematic review was elaborated to investigate the recent surgical trends in ACL reconstruction within worldwide national societies of orthopaedic surgeons.

Search Strategy

A systematic review was performed in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) guidelines.[13] A systematic search of the PubMed, Web of Science, and the Cochrane Library electronic databases was performed and updated until September 25, 2017. The search terms were mapped to Medical Subject Headings (MeSH) terms where possible. Search terms were entered under two topic: topic 1—(ACL) OR (anterior cruciate ligament); topic 2—(survey) OR (trends). Each topic was then combined with the 'AND' operator to produce the search strategy.

Two authors reviewed the title and abstract of each identified article to be selected. When the eligibility was unclear by title and abstract, the full text of the article was obtained and evaluated for eligibility.

Selection Criteria

Studies obtained from the search were included in the systematic review according to the specific inclusion and exclusion criteria. Inclusion criteria were surveys on ACL reconstruction trends and preferences, national surveys involving a national society of orthopaedic surgeons, report on the preferred graft for ACL reconstruction, surveys published in the past 5 years (2011–2016), and surveys published on peer-reviewed journals and written in English.

Exclusion criteria were as follows: lacking or equivocal data on graft preference (no answer or more than one answer available) and surveys involving members of different nations. In case of multiple surveys investigating the same population, only one survey was included in the review according to the following criteria: the most recent, the widest population, and the completeness of data regarding primary and secondary outcomes. The references of the relevant papers were screened to search additional studies to include in the review.

Data Extraction

The following data were obtained from the selected surveys: year and national society of the participants involved in the survey, number of sent surveys and following responses, and method of survey. The surveyed population was described considering professional status (dedicated fellowship and subspecialties), ACL procedures performed per year, and years of experience. Regarding surgical preferences, extracted data were graft choice, use of single- or double-bundle technique, preference for femoral tunnel drilling, fixation methods, and use of antibiotic and anti-thromboembolic prophylaxis, tourniquet, and drains.

Quality Assessment

The quality of the survey was evaluated using a five-item scoring system based on a binary outcome (yes\no) appositely developed for the purpose of this systematic review. It consisted of the following items: response rate >50%, surveyed members >100, systematic invitation of representative participants of the nation, surgical experience of surveyed members (ACL procedures per years and/or years

of experience), and completeness of results presentation (all items reported as percentage, no charts).

Results

Search Results

After the initial search, 31 surveys related to ACL reconstruction were obtained. Thirteen papers were excluded because these had been published before 2011. Of the remaining 18 surveys, 2 were excluded because they evaluated the same population,[14,15] 3 because they reported the preference of members of multiple nations or international societies,[16–18] 4 were excluded because they evaluated the preferences for the reconstruction exclusively in athletes,[19–22] and 1 was excluded because data regarding graft choice were not accurately reported.[23] Finally, eight surveys were included in the final systematic review (►**Fig. 1**).[24–31]

Surveys Methodologies and Populations Surveyed

All except one survey were performed systematically inviting the members of a specific orthopaedic national society through a personal invitation via Internet. In these cases, the surgical preferences were collected through an online survey. Only Ambra et al directly invited the members of the national society to fill a paper survey during the society meeting.[26] All surveys investigated the ACL reconstruction preferences related to an unspecific general population (►**Table 1**).

Three surveys evaluated European countries, three North and Latin American countries, and, the remaining two Asian countries. All except one[26] surveyed the members of one or more national societies of orthopaedics or knee surgeons.

Overall, 7,420 questionnaires were sent, and 1,495 participants completed the survey, with a response rate ranging from 16.0 to 76.6%. When reported, the average numbers of ACL performed per years was <50 and the surgical experience <10 years for the surveyed subjects. Three surveys reported also subspecialty in knee surgery for most of the surveyed (►**Table 2**).

Quality Evaluation

Despite only one survey had a response rate $>50\%$, four (50%) surveys collected the preferences of >100 orthopaedic surgeons. A systematic invitation of all surveyed populations was performed in seven (87.5%) out of eight surveys. Also, the surgical experience in ACL reconstruction was investigated in 87.5% of the surveys; only one survey clearly presented all results of the proposed questions. The other seven surveys mostly utilized charts and figures for data presentation, providing imprecise or incomplete information related to several outcomes (►**Table 3**).

Surgical Preferences

Overall, all surveys reported HT autograft as the graft of choice for most of the surveyed participants, ranging from 45 to 89%. Bone-patellar tendon-bone (BPTB) was the second preferred choice, ranging from 2 to 41% (►**Fig. 2**). The allograft was the first choice for 2 to 17% of the surveyed population. Two surveys focused on graft choice in athletic population.[29,31] In one of them, BPBT was the first choice for 61% of surgeon in male high-demand athletes;[29] HTs were the preferred choice for female athletes (57%) in the same survey and the preferred choice overall in the second survey, albeit the use of BPTB remained more frequent in high-demand athletes than in the others (49 vs. 45%).[31]

Single-bundle reconstruction was the preferred technique in the four surveys that investigated this issue.[24–27,29]

Seven studies reported the technique for femoral tunnel drilling: five were in favor of anteromedial (AM) portal,[24,26,27,29,30] and the remaining two were in favor of trans-tibial technique.[28,31]

When reported, suspension systems for femoral fixation were the preferred choice in all but one survey, while screws was the preferred method for tibial fixation. Two surveys reported the preference of graft tensioning, which were in favor of manual tensioning. Two surveys reported agreement in the use of tourniquet for most of the surveyed surgeons, while no agreement was observed for antibiotic and anti-thromboembolic prophylaxis and the use of drains (►**Table 4**).

Discussion

This systematic review of national surveys about graft choice and surgical trends in ACL reconstruction was conducted considering restrictive inclusion and exclusion criteria.

We choose to perform such a rigorous survey because we all know that guidelines for the surgical management of ACL injuries are based on scientific findings rather than on expert opinion. Even more, we know how prospective randomized clinical trials (RCTs) are considered to provide the best quality of evidence in the medical literature and are definitely the source of data for systematic reviews and meta-analyses that guide clinical decision-making. The limit in ACL reconstruction is that adherence to evidence-based medicine is not always possible because high-quality evidence is not available or is inconclusive.[32] Thus, the absence of a clear evidence leads to inconsistencies among surgeons' clinical practice, trends, and recommendations in the literature.[16] According with such criteria, we were able to examined only eight studies despite the great number of studies published in the literature.

The most important finding reported in the present study is the preference of HT graft in all the nations, ranging from 45 to 95% of the clinicians surveyed. This global trend seems to reflect the general belief, confirmed by the Cochrane recommendations, of higher risk of anterior knee pain and extension loss using BPTB autografts, in spite of comparable results respect to HT autografts for knee stability.[33] This finding is even more resounding when we have a look to the historical passage in graft choice from BPBT to HTs in the two biggest surveys performed such as the ESA and Canadian survey. Indeed in the United States, historical supporter of the BPTB, an inversion of the trend

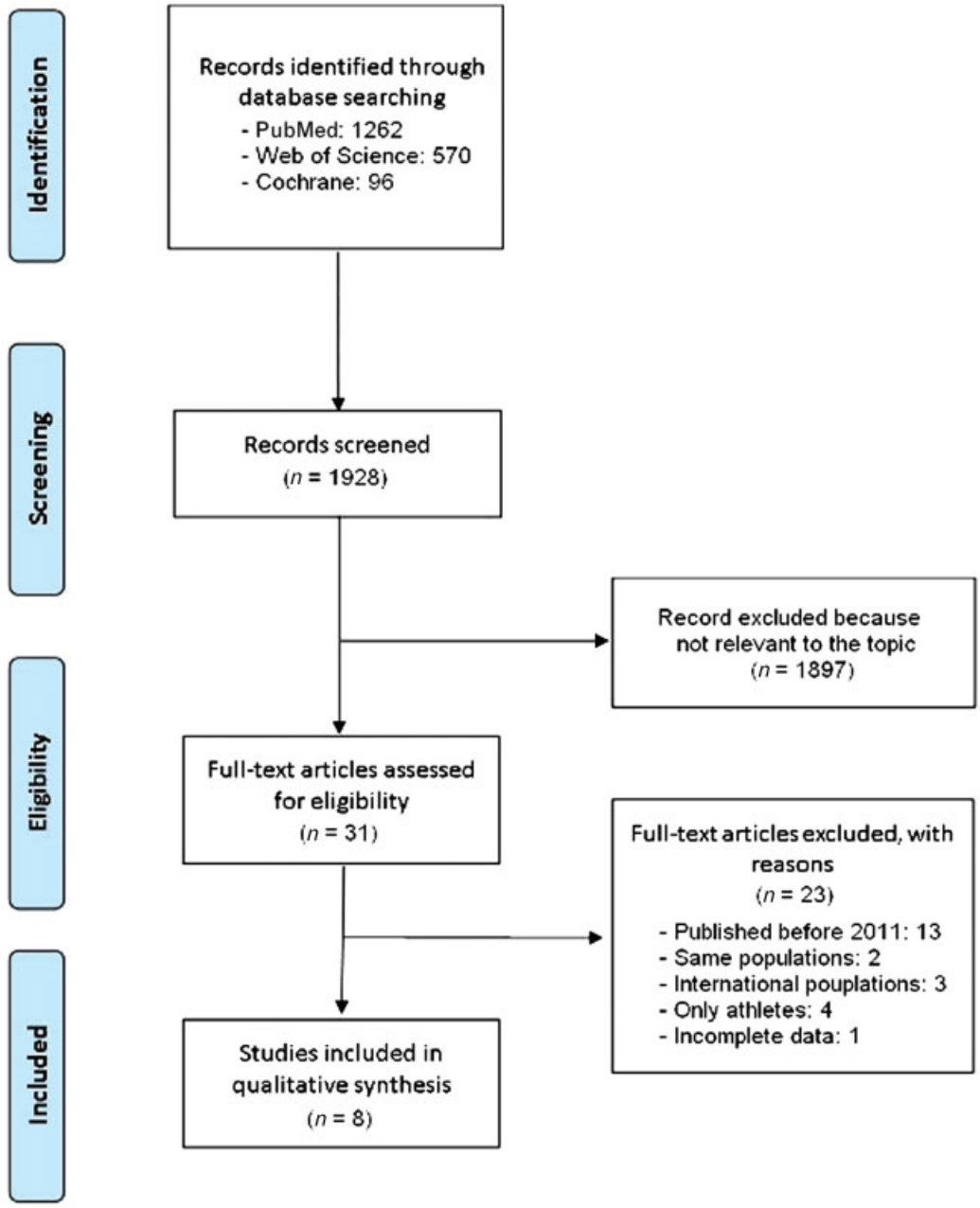

Fig. 1 Literature search flowchart according to the PRISMA guidelines. PRISMA, Preferred Reporting Items for Systematic reviews and Meta-Analysis.

has been registered in the most recent survey. In fact, surveys not included in this review, but conducted in the United States in 1999, 2001, and 2006, found that the use of BPTB autografts has progressively declined and that the use of HTs and allografts has risen,[34] despite that until 2011, BPTB autograft was still considered the preferred choice.[35–37] Also, the survey including the greatest number of participants, performed on an international population during the AAOS and EFORT 2011 meetings, revealed that HTs were the most popular graft choice (63%), followed by BPTB (26%) and allograft (11%).[16] As we previously underlined, this variation occurs in the context of an increasing number of RCTs and meta-analyses documenting the strengths and limitations of both approaches with no consensus on the choice of one over the other.[38–40] However, due to the recent evidences of higher failure rates with HT compared with BPTB autografts arisen form Scandinavian and US registries,[41–43] it could be possible to assist to a new trend inversion in favor of BPTB in the future. Moreover, several surveys highlighted the sport participation of patients to influence the graft choice toward BPTB autograft. In fact, BPTB seems to be the preferred graft among

Table 1 Description of the characteristics of the included surveys

Authors	Year	Target population	Nationality	Questionnaire method	Questionnaire collection	Questionnaires sent	Questionnaires received	Response rate	Investigated population
McRae et al	2011	Canadian Orthopaedic Association Members	Canada	Web	Personal invitation	576	144	49% (25% surveyed)	Unspecific
Mahnik et al	2013	Croatian Orthopaedics and Traumatology Association Members	Croatia	Web	Personal invitation	189	39	21%	Unspecific
Ambra et al	2015	Brazilian Congress of Knee Surgery 2014 Attendant	Brazil	Paper	Congress	NA	191	NA	Unspecific
Kirwan et al	2015	Australian Orthopaedic Association Members	Australia	Web	Personal invitation	192	83	43%	Unspecific
Van der Bracht et al	2015	Belgian Association for Orthopaedic Surgery Members	Belgium	Web	Personal invitation	119	45	38%	Unspecific
Grassi et al	2016	Italian Knee, Arthroscopy and Sports Traumathology Members	Italy	Web	Personal invitation	778	123	16%	Unspecific
Budny et al	2016	AOSSM and ANA US Members	USA	Web	Personal invitation	5488	824	19.2%	Unspecific
Vaishya et al	2016	DAS	India	Web	Personal invitation	60	46	76.6%	Unspecific

Abbreviations: AOSSM, American Orthopaedic Society for Sports Medicine; DAS, Delhi Arthroscopy Society; NA, not assessed.

the National Basketball Association (NBA),[22] National Football League (NFL),[20] and Major League Soccer (MLS) athletes.[21] Even in a survey conducted by Duquin et al,[34] among the members of the American Orthopaedic Society for Sports Medicine (AOSSM), it was found that the preferred graft for ACL reconstruction was BPTB autograft (46%) followed by HT (32%) and allografts (22%). The same concept has emerged from two of the surveys focusing on graft choice in athletic population included in our review.[29,31] In the United States survey,[29] BPBT was the first choice among 61% of surgeon in male high-demand athletes, whereas HTs remained the first choice for athletic women but with a lesser percentage than general population.[29] As the United States surgeons, Italian surgeons preferences shift to a high percentage of BPTB graft when treating professional athletes compared with the percentage of BPBT used for general population, even if HTs still remain the preferred choice for Italian surgeons (42%) regarding "sport and ACL reconstruction."[14]

Regarding the preferred technique for ACL reconstruction, single-bundle appeared the preferred choice for most of surgeons surveyed, probably because of the complexity of the double-bundle procedure in spite of a not proven superiority in terms of outcomes.[44] Anyway, this choice seems to have more anatomical and biomechanical reasons than those simply related to the complexity of the surgical procedure itself.

Indeed ACL reconstruction has evolved considerably over the past 40 years, and just at the real begins in the 1980s, the gold standard technique was a trans-tibial, AM bundle reconstruction, the so called "mismatch" reconstruction (tibial posterolateral [PL] bundle attachment and femoral AM bundle origin).[45–47] Even though this technique showed satisfactory and reliable clinical results over time, a certain amount of rotatory instability with a positive pivot shift test have been reported in up to 25% of cases.[48–51] This lacking of rotational control was confirmed by biomechanical studies,[51–53] and so in the 21st century, we assisted to a shift on ACL reconstruction focusing more on anatomic reconstruction[51,54,55] with the double-bundle procedure.[48,56,57] In the meanwhile, the better understanding of ACL anatomy and function has also led to modifications in single-bundle ACL surgery.[54] A single femoral tunnel positioned within the anatomic center of the native femoral footprint is supposed to recreate the function of both the AM and PL bundles, thus preventing clinical failure secondary to persistent instability.[53,58–60]

Among the studies investigating the technique for femoral tunnel drilling, most were in favor of AM portal technique. This could be due to the possible risk of suboptimal femoral tunnel placement using the trans-tibial technique when aiming to perform an anatomical single-bundle reconstruction.[61] The AM portal technique resulted more popular among the youngest and less experienced surgeons probably because they started their practice during the popularization of the technique and because they could be less familiar with the standard trans-tibial technique, which seems to be progressively abandoned.

Table 2 Details of the clinical experience of the surveyed participants

Authors	Year	Professional status	ACL per year	Years of experience
McRae et al	2011	NA	NA	13.2 years (mean)
Mahnik et al	2013	NA	75% <50 per year	56% <10 years of experience
			25% >50 per year	44% >10 years of experience
Ambra et al	2015	80% knee surgeons	3% <10 per year	45% <5 years of experience
		15% orthopaedic surgeons	13% 10–25 per year	25% 5–10 years of experience
		5% residents	37% 25–60 per year	12% 10–15 years of experience
			28% 60–120 per year	18% >15 years of experience
			19% >120 per year	
Kirwan et al	2015	NA	6% <10 per year	10% <15 years of experience
			10% 10–20 per year	16% 5–9 years of experience
			20% 21–30 per year	19% 10–14 years of experience
			10% 31–40 per year	13% 15–19 years of experience
			8% 41–50 per year	42% >20 years of experience
			46% >50 per year	
Van der Bracht et al	2015	29% knee surgeons	2% 0–10 per year	27% 0–5 years of experience
		56% knee + 1 other joint surgeons	22% 10–25 per year	11% 5–10 years of experience
		15% knee + 2 other joints surgeons	33% 25–50 per year	29% 10–20 years of experience
			27% 50–100 per year	33% >20 years of experience
			16% >100 per year	
Grassi et al	2016	NA	35% <25 per year	NA
			29% 25–50 per year	
			22% 50–100 per year	
			11% >100 per year	
Budny et al	2016	89.4% Subspecialty trained	NA	NA
Vaishya et al	2016	NA	27% <25 per year	NA
			27% 25–50 per year	
			15% 50–75 per year	
			31% >75 per year	

Abbreviations: ACL, anterior cruciate ligament; NA, not assessed.

Table 3 Evaluation of the survey quality and methodology

Authors	Year	Response rate >50%	Surveyed >100	Systematic invitation	Surveyed experience	Complete results
McRae et al	2011	N	Y	Y	Y	N
Mahnik et al	2013	N	N	Y	Y	N
Ambra et al	2015	N	Y	N	Y	N
Kirwan et al	2015	N	N	Y	Y	N
Van der Bracht et al	2015	N	N	Y	Y	N
Grassi et al	2016	N	Y	Y	Y	Y
Budny et al	2016	N	Y	Y	N	N
Vaishya et al	2016	Y	N	Y	Y	N

Abbreviations: N, No; Y, yes.

However, due to the most recent results of ACL registries, extreme caution should be used while interpreting this trend, since an almost two-fold failure rate has been reported with AM technique compared with the transtibial.[62] According to these data, the potential detrimental effect of the widespread use of AM technique should be accurately monitored in the following years through registries and long-term follow-up.

Analyzing the fixation methods, suspension systems for femoral fixation were the preferred choice in all but one survey, while screws were the preferred method for tibial fixation. Other variables such as tensioning, antibiotic and anti-thromboembolic prophylaxis tourniquet use, and drains were investigated scarcely among the surveys; therefore, no clear trends could be delineated. However, manual tensioning, administration of preoperative antibiotics, and tourniquet inflation seemed to be the preferred choices.

The main limitation of the present review is the limited number of included studies. However, applying strict inclusion criteria, we were able to select only the most recent surveys and to avoid including trends that could be considered not recent. Moreover, excluding multiple nations and international surveys, we had the opportunity to clearly describe national-specific trends and perspectives.

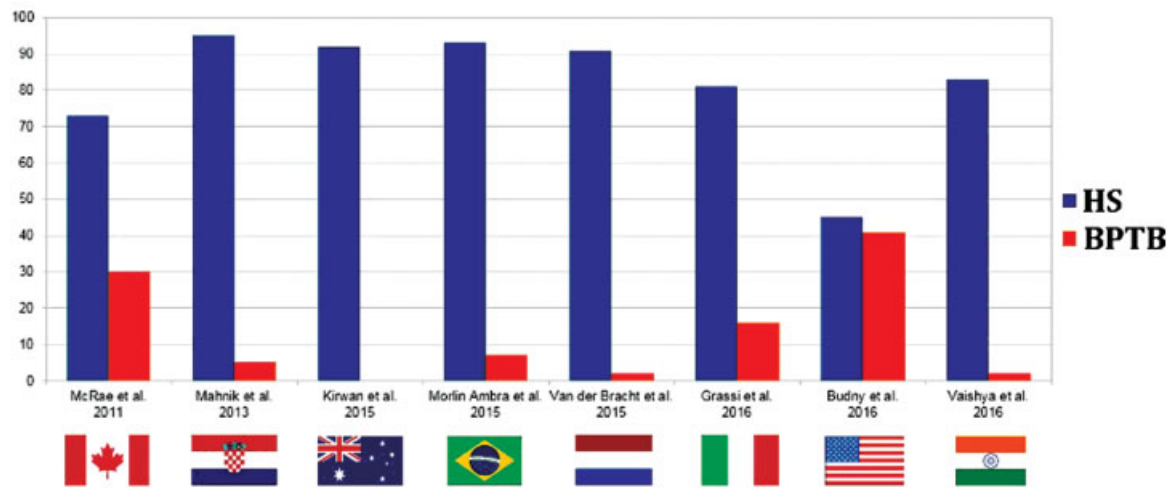

Fig. 2 Visual representation of the graft choice between HTs (blue bars) or BPTB (red bar) within the various national surveys. BPTB, bone-patellar-tendon-bone; HT, hamstring tendon.

Table 4 Details of the surgical preferences of the surveyed members

Authors	Year	Pre-op. requirement	Graft choice	Graft choice in athletes	Surgical technique	Femoral tunnel	Fixation methods	Tensioning	Antibiotics prophylaxis	Anti-thromboembolic prophylaxis	Tourniquet	Drains
McRae et al	2011	NA	73% HS	NA	54% SB	70% TT	51% Suspensory fixation	82% Manual	NA	NA	NA	NA
			30% BPTB		46% DB	28% AMP		18% Devices				
			7% Others									
Mahnik et al	2013	NA	95% HS	NA	NA	67% AMP	62% Suspensory fixation	NA	100% Yes	NA	NA	NA
			5% BPTB			33% TT	33% Transfix pin					
							5% Bioabsorbable Screws					
Ambra et al	2015	NA	93% HS	NA	NA	50% AMP	NA	NA	NA	NA	NA	NA
			7% BPTB			26% TT						
						24% 2-incisions						
Kirwan et al	2015	NA	92.4% HS	NA	NA	NA	NA	80% Manual tensioning	NA	NA	NA	28% (Public) Yes
			7.6% Others					51% Maximum one handed pull				31% (Private) Yes
								32% Submaximal one handed pull				
								79% Aimed to 41–60 N (manual) and 61–80 N (device)				
								38% (Manual) 27% (device) tensioning near full extension				
								21% (Manual) 40% (device) tensioning at 30°				
Van der Bracht et al	2015	NA	91% HS	NA	93% only SB	58% AMP	91% Suspensory fixation (femur)	NA	NA	NA	NA	NA
			2% BPTB		5% SB and DB	42% TT	9% Transfix pin (femur)					
			7% Allografts		3% Extra-articular rec.		91% Screw (tibia)					

Table 4 (*Continued*)

Authors	Year	Pre-op. requirement	Graft choice	Graft choice in athletes	Surgical technique	Femoral tunnel	Fixation methods	Tensioning	Antibiotics prophylaxis	Anti-thromboembolic prophylaxis	Tourniquet	Drains
							7% Transfix pin (tibia)					
							2% Suspensory fixation (tibia)					
							64% Backup fixation					
Grassi et al	2016	NA	81% HS	49% HS	NA	62% TT	NA	NA	NA	NA	NA	NA
			16% BPTB	45% BPTB		29% AMP						
			2% Allografts			9% Out-in						
			1% Synthetic									
Budny et al	2016	75.2% Full extension	45% HS	61% of male athletes: BPTB	92.3% SB	47% AMP	79.4% Screws (BPTB femur)	NA	51% Yes	47.7% Yes (92.4% enterically coated aspirin, 7.6 LMWH)	72.4% Yes	NA
			41% BPTB	57% of female athletes: HS	7.7% DB	22.9% Reverse drilling	13.4% Suspensory fixation (BPTB femur)		49% No		27.6% No	
			17% Allografts			22.8% TT	98.1% Screws (BPTB tibia)					
							79% Suspensory fixation (HS femur)					
							7.9% Screws (HS femur)					
							85.9% Screws (HS tibia)					
Vaishya et al	2016	22.9% <3 weeks	83.3% HS	NA	83.3% SB	86.9% AMP	93.75% Suspensory fixation (femur)	NA	NA	NA	93.7% Yes	NA
		47.9% 3–6 weeks	2.1% BPTB		10.4% DB	10.4% TT	95.83% Screws (tibia)				6.3% No	
		29.2 $>$ 6 weeks										

Abbreviations: AMP, anteromedial portal; BPTB, bone-patellar tendon-bone; DB, double-bundle; HS, hamstrings; LMWH, low molecular weight heparin; N, Newton; NA, not assessed; SB, single-bundle; TT, transtibial.

Conclusion

In conclusion, a trend toward the preference of HT autograft was registered in all the surveys; however, sport participation has been highlighted as an important variable for increased use of BPTB. Single-bundle reconstruction with AM portal technique and suspension femoral fixation and screws fixation for the tibia seem the preferred solution. Other variables such as tensioning, antibiotic and antithromboembolic prophylaxis, tourniquet use, and drains were investigated scarcely among the surveys; therefore, no clear trends could be delineated.

Conflict of Interest
None declared.

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