

An international survey on anterior cruciate ligament reconstruction practices

Ofir Chechik · Eyal Amar · Morsi Khashan ·
Ran Lador · Gil Eyal · Aviram Gold

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Abstract

Purpose Bone-patellar-tendon-bone (BPTB) autografting fixed with metal interference screws (IS) is the gold standard for anterior cruciate ligament (ACL) reconstruction. Advances in surgical technology provide a wide choice of grafts, fixation devices and surgical approaches.

Methods Two-hundred and sixty-one orthopedic surgeons of ten subspecialties from 57 countries were surveyed on their choice of graft and fixation device, the number of reconstructed bundles, and arthroscopic portal. Their preferences were analyzed according to country of origin, field of expertise and seniority, and compared to current publications.

Results Hamstring autografting was the most popular choice (63 %), then BPTB (26 %) and allograft (11 %). The anteromedial portal was preferred over the traditional transtibial portal (68 % versus 31 %). Two-thirds reported routinely performing a single-bundle graft reconstruction, compared to one-third who used the double-bundle technique. The Endo-button was the most common graft fixation method (40 %), followed by the bioabsorbable IS (34 %), metallic IS (12 %), rigidfix (10 %) and others (4 %). The preferences of hamstring tendon grafting and the anteromedial portal are not supported in the literature. Responses from North American and European surgeons were different from all the others.

Conclusions Surgeon preferences in ACL reconstruction differ considerably worldwide. Common practice is not always supported by evidence-based publications.

Introduction

Approximately 300,000 anterior cruciate ligament (ACL) reconstructions are performed in the USA alone each year [7]. Historically, ACL reconstructions were performed using bone-patellar-tendon-bone (BPTB) autografts fixed with metal interference screws (IS). BPTB autografts have been considered the gold standard to which other technologies are compared [3, 20, 23]. The goals of ACL reconstruction are to restore knee stability, prevent further damage to knee structures and improve functional outcome. The evolution of surgical technology to reach these goals provide the surgeon with choice of a variety of grafts, fixation devices and surgical techniques [1]. Guidelines for diagnosis, treatment and prognosis are ostensibly based on scientific findings rather than on the opinions of experts. Prospective randomized clinical trials are considered the best quality of evidence in the medical literature, and they are the source for systematic reviews and meta-analyses, together comprising the level-I evidence and guiding clinical decision making [17, 24]. While physicians are expected to consider such evidence, other factors, such as marketing, peer pressure, preliminary data or lower quality of evidence and tradition also influence decision making [17]. This may be more conspicuous in areas where high-quality evidence is not available or where evidence is inconclusive [24]. Another difficulty with the scientific approach of evidence-based medicine lies in interpreting the outcomes. Clinician-reported outcomes may differ considerably from patient-reported outcomes, making it all that more difficult to judge the advantages of one approach over the other [24].

O. Chechik (✉) · E. Amar · M. Khashan · R. Lador · A. Gold
Department of Orthopedic Surgery,
Tel Aviv Sourasky Medical Center,
Tel-Aviv, Israel
e-mail: ofirchik@yahoo.com

G. Eyal
Department of Orthopedic Surgery, Rabin Medical Center,
Petah Tikvah, Israel

The purpose of this survey was to determine the current trends and common practice in selected issues regarding ACL reconstruction surgery. We hypothesized that a surgeon's experience, country of origin and area of expertise would influence choices, together with published level-1 evidence.

Methods

A "Pubmed" search was conducted in January 2011 using the key words "anterior cruciate ligament" + "reconstruction," and limited to "randomized controlled trials" or "meta-analysis". Four parameters of surgical techniques of ACL reconstruction for which there were either meta-analyses or at least two randomized controlled trials were chosen for analysis, and the questionnaire was comprised of four multiple choice questions on the surgeon's preferences regarding these issues.

The first question addressed the preferred type of graft (patellar tendon, hamstring tendon or allograft). The second addressed the surgical approach for drilling the femoral tunnel (anteromedial arthroscopic portal [AMP], arthroscopic transtibial or open). For the third question, the surgeons were asked to choose between a single-bundle and a double-bundle technique, and for the fourth question, they were asked to choose their favorite instrument for graft fixation (metallic interference screw [IS], bioabsorbable IS, Endo-button, rigidfix or other). The responders were also asked to provide their country of origin, field of specialty, number of years of experience and professional status (i.e., senior surgeon, fellow or resident).

The survey (Table 1) was distributed to orthopedic surgeons at two major international conferences held in the United States and Europe: The Annual Meeting of the American Academy of Orthopedic Surgeons (AAOS) held in San Diego, February 2011, and the 12th EFORT held in Copenhagen, June 2011.

Statistics

A univariate analysis was performed using the Chi-square test to detect significant differences in choices between surgeons from different regions of the world (North America, Europe or other), different subspecialties (sports and knee surgery and other), and different levels of experience (seniors, fellows or residents).

Results

A total of 261 surgeons of ten sub-specialties, comprised of 64 % senior surgeons, 22 % residents, and 14 % fellows

Table 1 International survey on anterior cruciate ligament reconstruction techniques. Orthopedic surgeons were asked to respond to the following questions, by circling their answers: In ACL reconstruction what are your choice of graft, approach, technique and method of fixation (respectively)?

| |
|-----------------------------------|
| Choice of graft |
| Allograft |
| Hamstrings |
| Patellar tendon |
| Other |
| Choice of approach |
| Transtibial arthroscopic |
| Anteromedial arthroscopic |
| Open |
| Technique |
| Single bundle |
| Double bundle |
| Method of fixation |
| Bioabsorbable interference screws |
| Metallic interference screws |
| Endo-button |
| Rigidfix |
| Other |

from 57 countries (53 % European, 23 % North American, 7 % Asian, 7 % South American, 7 % Middle East and 2 % African) took part in this survey. The average level of experience was 10.8 years (range 0–45), and 20 % were either knee or sports surgeons.

The response rate was 93 %, 54 %, 59 % and 68 % for questions one through four, respectively. In response to the first question on graft preference, 63 % chose a hamstring tendon graft, 26 % chose a patellar tendon graft and 11 % favored allografts. North American surgeons favored hamstring tendon grafting significantly less than all other surgeons (42 % compared to 72 % of Europeans, $P=0.0005$, and 66 % of those from other countries, $P=0.02$). The most preferred surgical approach for drilling the femoral tunnel was the AMP (68 % of responders), followed by the transtibial (31 %) and open (1 %). There were no significant differences based on geographic origin, specialty or seniority.

Two-thirds (67 %) of the responders reported that they routinely perform a single-bundle graft reconstruction compared to 33 % who use the double-bundle technique. Specifically, only 11 % of North American surgeons preferred a double-bundle reconstruction, compared to 42 % of European surgeons ($P=0.001$) and 37 % of the surgeons from other parts of the world ($P<0.01$). In addition, only 13 % of surgeons who described themselves as being knee or sports specialists responded that they perform a double-bundle reconstruction, compared to 35 % of surgeons from other subspecialties ($P=0.03$).

The Endo-button was most commonly chosen method of graft fixation (40 %), followed by the bioabsorbable IS (34 %), metallic IS (12 %), rigidfix (10 %) and other devices (4 %). There were no significant differences based on geographic origin, specialty or seniority. Detailed results are described in Table 2.

Discussion

The purpose of this survey was to investigate which were the common practices in ACL reconstruction surgery among orthopedic surgeons worldwide, and to determine whether their choices are supported by published evidence-based data and/or affected by country of origin, area of expertise and length of experience.

Graft choice

An ideal ACL graft is one that is easily harvested, results in little harvest site morbidity, is biomechanically comparable to the native ligament, can be secured predictably and rapidly incorporates to the bones [23]. Most surgeons reportedly prefer autograft over allograft for ACL reconstruction: the use of allograft for ACL reconstruction has gained increasing popularity and is now estimated to be used in 20–30 % of primary reconstructions in the USA [3, 9]. Although they are associated with no harvest site morbidity, and provide predictable graft size, shorter operative time and easier recovery in the postoperative period, allografts are considered more likely to fail

because of decreased mechanical properties due to sterilization and the possibility of triggering an inflammatory response [3, 9]. Furthermore, some patients refuse to consent to their use because of the risks of disease transmission or psychological factors [3, 9, 16].

Our survey findings showed that about 11 % of the surgeons prefer allograft over autograft, a rate that is similar to previous reports [3, 9]. A meta-analysis that included six randomized controlled trials with 534 patients compared BPTB autografts and allografts [16]. Although the use of allografts was associated with increased graft failure rates, the reoperation rates, translation and rotational stability and functional outcome were similar [16].

The two most widely used autografts are BPTB grafts and hamstring tendons. Typically, hamstrings are associated with less anterior knee pain and better extension, making their use more popular [5, 20]. Hamstring grafting also allows separation of the graft to perform double-bundle reconstruction, which BPTB grafting does not [1]. On the other hand, a BPTB graft has an excellent initial fixation and improved graft incorporation related to bone-to-bone healing [16, 20], but its use may also be associated with patellofemoral pain and (rarely) patellar fractures [23].

Another meta-analysis of six randomized controlled trials with 423 patients found that reconstruction using BPTB autografts is associated with better rotational stability (lower rates of positive pivot shift), compared to hamstring autografts [5]. A systematic review by Reinhardt et al [20] compared BPTB autografts to hamstring grafts, and their results suggested that failure rates were significantly higher with the use of hamstrings (15.8 % versus 7.2 %), but that

Table 2 Results of International survey on ACL reconstruction by geographic region

| | North America | Europe | Other countries | Total |
|---------------------------|---------------|-----------|-----------------|------------|
| Choice of graft | | | | |
| Allograft | 11 (19 %) | 11 (9 %) | 4 (7 %) | 26 (11 %) |
| Hamstrings | 25 (42 %) | 88 (72 %) | 39 (66 %) | 152 (63 %) |
| Patellar tendon | 23 (39 %) | 23 (19 %) | 16 (27 %) | 62 (26 %) |
| Choice of approach | | | | |
| Transtibial arthroscopic | 12 (32 %) | 24 (35 %) | 6 (19 %) | 42 (31 %) |
| Anteromedial arthroscopic | 24 (63 %) | 43 (63 %) | 26 (81 %) | 93 (68 %) |
| Open | 1 (3 %) | 1 (1 %) | 0 | 2 (1 %) |
| Technique | | | | |
| Single bundle | 32 (89 %) | 43 (58 %) | 26 (63 %) | 101 (67 %) |
| Double bundle | 4 (11 %) | 31 (42 %) | 15 (37 %) | 50 (33 %) |
| Method of fixation | | | | |
| Bioabsorbable IS | 14 (35 %) | 31 (36 %) | 17 (32 %) | 62 (34 %) |
| Metallic IS | 9 (23 %) | 4 (5 %) | 8 (15 %) | 21 (12 %) |
| Endo-button | 14 (35 %) | 36 (41 %) | 22 (42 %) | 72 (40 %) |
| Rigidfix | 1 (3 %) | 12 (14 %) | 5 (9 %) | 18 (10 %) |
| Other | 2 (4 %) | 4 (5 %) | 1 (2 %) | 7 (4 %) |

anterior knee pain was more common with the use of BPTB [20]. Other studies that compared four-stranded hamstring grafts to BPTB autografts showed similar stability and functional results [18, 20]. Some authors concluded that given the high rates of kneeling pain, anterior knee pain and patellofemoral pain, BPTB autografts should be avoided in patients whose occupation or lifestyle requires frequent kneeling [21, 23].

The responses to our survey revealed that hamstring tendon grafting is more popular than the traditional BPTB grafting, and more so outside of the United States. This preference is contrary to tradition and history, and is not strongly supported in the literature. Surveys conducted in the USA in 1999, 2001 and 2006 found that the use of BPTB autografts has progressively declined and that the use of allografting and hamstring grafting has risen [12]. Hamstrings were also more commonly preferred among younger (less than five years of practice) surgeons [12]. Since the harvesting procedure of hamstring and BPTB grafts takes about the same time and does not involve extra cost in either case, we hypothesize that the explanation for this result lies in the high rate of complications (i.e. anterior knee pain) following the harvest of BPTB grafts, driving surgeons away from this choice of graft material. Also, a hamstring graft is preferred over a BPTB graft for a double-bundle reconstruction, another aspect possibly contributing to a shift toward choosing hamstrings.

Surgical approach for drilling the femoral tunnel

Three main surgical procedures are available to repair the ACL: mini-arthrotomy open, two incision arthroscopically assisted and one-incision endoscopic, with the latter being the most popular [1]. The main cause of ACL reconstruction failure has been non-anatomical tunnel placement. Both anterior and vertically oriented femoral tunnels are associated with anteroposterior and rotational laxity [1]. An ideal portal should allow anatomic placement of both tibial and femoral tunnels, while minimizing complications. The use of a transtibial portal for femoral tunnel drilling may limit the surgeon's ability to achieve anatomic position and result in an anterior/superior femoral tunnel starting point [1, 4]. The tibial tunnel can be modified (modified transtibial technique) and moved medially to avoid vertical femoral tunnels [23]; but even then, when the femoral tunnel is accurately placed, the tibial tunnel may be compromised and placed too posteriorly, resulting in a vertical graft on the sagittal plane [6]. The use of an arthroscopic AMP for femoral drilling, with the knee in hyperflexion, allows a more accurate posterior and horizontal placement of the femoral tunnel by keeping any bony structures from limiting the drills and allowing the two tunnels (tibial and femoral) to be placed independently [1, 4, 19]. The use of AMP has been

demonstrated to accurately restore the native ACL position [6] and achieve better stability in cadaveric knees [4]. Its potential disadvantages, on the other hand, include the creating of short sockets, posterior wall blowout, distal/inferior exit in the lateral thigh endangering the peroneal nerve, possible impingement of the aimer at the inter-condylar notch throughout the entire range of motion, possible damage to the medial femoral condyle cartilage and other technical difficulties [19]. In fact, a retrospective study that compared femoral tunnel position and length found that tunnels drilled by using AMP were significantly shorter and more oblique, and that a larger rate of the tunnels were shorter than 30 mm, compared to the transtibial technique [7]. Nevertheless, the AMP approach has gained popularity since it was first introduced a few years ago, and its use has expanded [19].

No significant differences in outcome scores were found in a review of 21 studies comparing the clinical results of either the transtibial or AMP techniques among 859 patients [1]. However, although the patients operated by the AMP technique had improved range of motion in the early period, earlier return to athletic activities and greater (manual and instrumental) knee stability at the one to two year follow-up, they also had a higher rate of graft failure compared to those who were operated by the transtibial technique (5.7 % versus 2.3 %, respectively) [1].

A survey conducted in the USA in 2006 found that 90 % of surgeons perform a single-incision arthroscopic ACL reconstruction and, of those, 85 % still prefer the transtibial approach, while only 15 % perform an AMP approach [12]. In contrast, our worldwide survey found that 68 % prefer the AMP over a transtibial approach, a finding that is not supported by the published data, and we speculate that this is because the AMP technique has advantages that were not described or proven in trials, but may nevertheless be apparent to clinicians. Some surgeons may think that it allows more accurate anatomic placement of the femoral tunnel and better restoration of the posterolateral bundle, thus providing better rotational stability. We expect that this will eventually be reflected by new evidence in the literature.

Double-bundle and single-bundle technique

The double-bundle ACL reconstruction technique aims to provide an anatomic substitution of the native ACL. By using two separate grafts, both the anteromedial and the posterolateral bundles can be restored, providing good stability throughout the entire range of motion. Specifically, rotational stability is better restored by means of this technique than by a single bundle graft [22, 25, 26]. On the other hand, double-bundle reconstructions are more difficult to perform and require longer operative time. Comparative clinical trials also showed that anterior tibial translation is

smaller and that pivot shift is more often negative with the use of a double-bundle technique [26]. Araki et al. found better rotational stability with the use of double bundle, compared with anatomic single bundle reconstruction [2]. Criticism of these results are that while a 1–2 mm side-to-side difference of anterior tibial translation may be statistically significant, this may not influence knee function on the clinical level. Also, the pivot shift test that is used to measure rotational stability is not a quantitative but rather a manual subjective test, therefore making statistical analysis of the results is difficult [26]. We found that 33 % of all surveyed surgeons prefer to use the double-bundle technique in their reconstructive surgeries. This technique was more often preferred by surgeons practicing in Europe (42 %) and other parts of the world (37 %) compared to North American surgeons (11 %).

While there are a number of well-designed studies showing that the double-bundle technique provides better knee stability, its main disadvantage is that it is technically difficult and involves additional surgical time. We speculate that, compared to other countries, many surgeons in the American health system work independently (i.e., not within an academic centre) and perform a wide variety of procedures, and that they will tend to avoid difficult, complicated or time-consuming procedures. Finally, we found that surgeons who are specialists in sports and knee surgery do not prefer the double-bundle technique, although they probably have the expertise to perform it. We have no explanation for this finding.

Graft fixation

Graft fixation methods can be divided to suspensory, joint line or transfemoral [10]. With the use of BPTB or quadruple hamstring tendon grafts that exceed the mechanical strength of the native ACL, graft fixation becomes the weakest link, and the most probable site of failure after ACL reconstruction. The trend towards early rehabilitation with immediate weight bearing and full range of motion, as well as early return to athletic activity, add to the risk of failure [8, 10, 13]. The fixation device must provide strong enough fixation to allow early rehabilitation with minimal movement of the graft until biologic fixation is complete. Biologic fixation with a BPTB graft (bone-to-bone healing) is thought to be quicker than that of all-tendon grafts [23]. While some biomechanical studies suggested that suspensory fixation (such as Endo-button) are strongest in terms of load to failure [10], others showed that the further the fixation point from the joint line, the more it allows the graft to elongate under cyclic loading [13].

Peripheral fixation was also found to lead to more tunnel widening, possibly because it allows graft motion within the canal, a phenomenon known as the "bungee effect" [10, 13].

Fixation of the aperture attempts to recreate the native anatomic ACL fixation points, and it provides a stiffer construct with less chance of graft motion and less tunnel widening. Clinical outcomes have not differed when those different methods were compared [13]. No significant differences in clinical outcomes were found between aperture and other fixation methods in a meta-analysis that included eight studies, although there was a non-significant trend toward a lower failure rate with the use of IS ($P=0.15$) [9]. Metallic IS is the longtime gold standard of graft fixation [8, 14, 23] and it was the most preferable choice of surgeons until 1999 [11]. Bio-absorbable and bio-composite materials have been used to make the screws and those materials typically provide adequate strength over the three to four months required for graft incorporation. In addition to dissolving gradually, bio-absorbable IS allow magnetic resonance imaging with fewer artefacts and image distortion. They are also better handled during revision surgery [23]. On the other hand, bio-absorbable IS have been reported to break intra-operatively and to possibly initiate an inflammatory response, contributing to tunnel widening [14]. In some cases these screws provoke inflammatory response and pain and require surgical removal [15]. In a meta-analysis of eight studies (745 patients) that compared bio-absorbable IS to metallic ones, intra-operative complications were more common with the use of the former ($P=0.179$), but the clinical outcomes did not differ [10].

We found no consensus among surgeons on the choice of a fixation device. Joint line fixation and suspensory fixation were almost equally used (40 % versus 46 %, respectively), and bio-absorbable were preferred over metallic screws (34 % versus 12 %, respectively). When compared to a survey conducted in the USA in 2006 [10], the Endo-button seems to have gained popularity: 40 % of our responders had chosen to use the Endo-button while in 2006 it was only rarely selected.

Conclusions

This survey identified a trend toward the use of hamstring tendon autografts and the AMP approach for drilling the femoral tunnel, representing a shift from the more traditional BPTB graft and transtibial approach in ACL reconstruction. Interestingly, neither the use of hamstring grafts nor of the AMP are well supported by evidence-based data in the published literature. In spite of its proven provision of superior stability, the double-bundle technique has yet to become the gold standard of ACL reconstruction. Our survey results showed that geography affects surgeon preferences, as demonstrated by distinctly different choices of North American surgeons compared to

others worldwide. Finally, there appears not to be much correlation between scientific evidence and common practice in the field of ACL reconstruction surgery.

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