

# Orthopedic Practice Patterns Relating to Anterior Cruciate Ligament Reconstruction in Elite Athletes

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## Abstract

We conducted an online survey of National Hockey League (NHL), Major League Soccer (MLS), and US Olympic/World Cup Ski/Snowboard (Olympic) team orthopedic surgeons to determine practice patterns relating to anterior cruciate ligament (ACL) reconstruction in elite athletes.

Of the 94 team orthopedic surgeons surveyed, 47 (50%) responded. Mean (SD) experience as a team physician was 7.73 (5.33) years for NHL, 6.77 (6.64) years for MLS, and 1.14 (0.36) years for Olympic. Mean (SD) number of ACL reconstructions performed in 2012 was 101 (51) for NHL, 78 (38) for MLS, and 110 (105) for Olympic. Overall, 33 surgeons (70.2%) indicated they would use bone–patellar tendon–bone (BPTB) autograft to treat their starting athletes. Twenty-one (44.7%) drilled the femoral tunnel through a transtibial portal, 36.2% through an anteromedial portal, and 12.8% by a 2-incision technique. All the surgeons used a single-bundle technique. Thirty-three (70.2%) did not recommend a brace for their elite athletes during play on return to sport (RTS). Twenty-seven NHL and MLS surgeons (81.8%) recommended RTS only after an athlete has passed a series of RTS tests (eg, Vail, single-leg hop).

Most of the NHL, MLS, and Olympic team orthopedic surgeons who were surveyed perform their ACL reconstructions using BPTB autograft, using a single-bundle technique, and through a transtibial portal, and do not require bracing for their athletes returning to sport. Most required their athletes to complete a series of RTS tests before resuming competitive play.

for a total of 51 teams and a rough total of 2229 athletes (1500 NHL, 570 MLS, 159 Olympic).<sup>1</sup>

Studies have shown that MLS athletes and X-Game skiers and snowboarders have performed well on return to sport (RTS) after anterior cruciate ligament (ACL) reconstruction.<sup>2,3</sup> However, the techniques, graft choices, and rehabilitation protocols used to return these elite athletes to their preinjury level of performance have not been elucidated. It is unclear if the treatment given to these elite athletes differs from that given to recreational athletes and nonathletes. Bradley and colleagues<sup>4</sup> examined how 32 NFL team orthopedists treated ACL tears, and Erickson and colleagues<sup>5</sup> recently surveyed NFL and National Collegiate Athletic Association (NCAA) team physicians to determine practice patterns (eg, surgical techniques, graft choices, postoperative protocols) in treating ACL tears. Until now, however, no one has examined NHL, MLS, or Olympic team orthopedic surgeons' practice patterns as they relate to ACL reconstruction.

We conducted an online survey of NHL, MLS, and Olympic team orthopedic surgeons to determine practice patterns relating to ACL reconstruction in elite athletes. Given the practice patterns of surgeons in our practice, we hypothesized that the surveyed surgeons treating these elite athletes would most commonly use bone–patellar tendon–bone (BPTB) autograft with a single-bundle technique. We also hypothesized that they would permit RTS without a brace at a minimum of 6 months after surgery, with a normal physical examination, and after successful completion of a structured battery of RTS tests.

## Materials and Methods

On the SurveyMonkey website (<http://www.surveymonkey.com>), we created a 7-question base survey, with other questions added for the NHL and MLS surveys (Figure 1). We sent this survey to 94 team orthopedic surgeons (41 NHL, 26 MLS, 27 Olympic) identified through Internet searches and direct contact with team public relations departments. The survey was approved by MLS and NHL research committees. In 2013, each survey was sent out 5 times. The response rates for each round are shown in Figure 2. All responses remained confidential; we did not learn surgeons' identities. Data were col-

National Hockey League (NHL), Major League Soccer (MLS), and US Olympic/World Cup Ski/Snowboard (Olympic) athletes receive orthopedic care from a select group of surgeons. There are 30 NHL teams, 19 MLS teams, 1 Olympic ski team, and 1 Olympic snowboard team,

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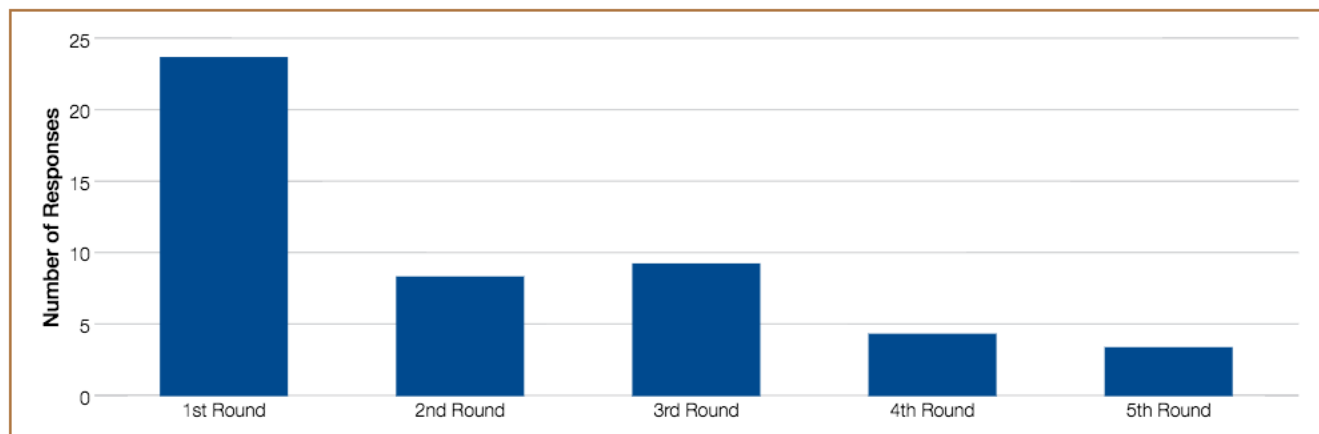
### Base Survey

1. For how many years have you been an (MLS, NHL, Olympic) team orthopedic surgeon?
2. In 2012, approximately how many ACL reconstructions did you perform?
3. During ACL reconstruction for a 20-year-old starting (NHL, MLS, Olympic) athlete, what is your preferred graft choice?
  - a. Bone–patellar tendon–bone autograft
  - b. Bone–patellar tendon–bone allograft
  - c. 4-strand semitendinosus autograft
  - d. Quadriceps autograft
  - e. Achilles allograft
  - f. Tibialis anterior allograft
  - g. Other (please specify):
4. During ACL reconstruction for a 25-year-old recreational athlete, what is your preferred graft choice?
  - a. Bone–patellar tendon–bone autograft
  - b. Bone–patellar tendon–bone allograft
  - c. 4-strand semitendinosus autograft
  - d. Quadriceps autograft
  - e. Achilles allograft
  - f. Tibialis anterior allograft
  - g. Other (please specify):
5. During ACL reconstruction for your starting (NHL, MLS, Olympic) athlete, do you prefer femoral tunnel drilling through an anteromedial portal or a transtibial portal?
  - a. 2-incision technique
  - b. Transtibial portal
  - c. Anteromedial portal
  - d. Other
6. During ACL reconstruction for your starting (NHL, MLS, Olympic) athlete, do you prefer single-bundle or double-bundle ACL reconstruction?
  - a. Single-bundle
  - b. Double-bundle
7. Once your starting (NHL, MLS, Olympic) athlete has returned to sport after ACL reconstruction, do you recommend use of a knee brace during sport?
  - a. Yes
  - b. No

### Other Questions Added to NHL Survey and MLS Survey

1. During ACL reconstruction for a 35-year-old recreational athlete, what is your preferred graft choice?
  - a. Bone–patellar tendon–bone autograft
  - b. Bone–patellar tendon–bone allograft
  - c. 4-strand semitendinosus autograft
  - d. Quadriceps autograft
  - e. Achilles allograft
  - f. Tibialis anterior allograft
  - g. Other (please specify):
2. After ACL reconstruction for your starting (NHL, MLS) athlete, what criteria do you use to permit return to sports in a regular-season, competitive game–type setting? Please select all answers that apply.
  - a. Minimum 6 months after surgery
  - b. Minimum 9 months after surgery
  - c. Minimum 12 months after surgery
  - d. Normal range of motion, no pain, full strength, and subjective stability
  - e. Passed a series of return-to-sport tests (eg, Vail, single-leg hop)
  - f. Other (please specify):

**Figure 1.** Questionnaire administered, including 7-question base survey, with other questions added to National Hockey League and Major League Soccer surveys. Abbreviations: ACL, anterior cruciate ligament; MLS, Major League Soccer; NHL, National Hockey League; Olympic, US Olympic/World Cup Ski/Snowboard.



**Figure 2.** Number of responses per round of survey emails.

lected and analyzed through the SurveyMonkey website. Each surgeon was instructed to respond to all relevant questions in the survey. The survey was designed such that the participant could not submit the survey without answering all the questions. Descriptive statistics were calculated for each study and parameter analyzed. Continuous variable data are reported as means and standard deviations (weighted means where applicable). Categorical data are reported as frequencies with percentages.

**Results**

Of the 94 team orthopedic surgeons surveyed, 47 (50%) responded (NHL, 49%; MLS, 50%; Olympic, 52%). Mean (SD) experience as a team physician was 7.73 (5.33) years (range, 2-20 years) for NHL, 6.77 (6.64) years (range, 2-20 years) for MLS, and 1.14 (0.36) years (range, 1-10 years) for Olympic. Mean (SD) number of ACL reconstructions performed in 2012 was 101 (51) for NHL (range, 50-200), 78 (38) for MLS (range, 20-150), and 110 (105) for Olympic (range, 25-175) (Table 1). Of the 47 surgeons, 42 (89.4%) used autograft in the treatment of elite athletes, and 5 (10.6%) used allograft. Autograft choices were BPTB (n = 33; 70.2%), 4-strand semitendinosus (n = 7; 14.9%), and quadriceps (n = 2; 4.3%); allograft

choices were 4-strand semitendinosus (n = 4; 8.5%) and BPTB (n = 1; 2.1%) (Table 2).

Of the 40 surgeons (85.1%) who indicated they would use autograft in 25-year-old recreational athletes, 25 (53.2%) would use BPTB, 13 (27.7%) would use 4-strand semitendinosus, and 2 (4.3%) would use quadriceps; of the 7 who indicated they would use allograft, 4 (8.5%) would use 4-strand semitendinosus, and 3 (6.4%) would use BPTB. In the NHL and MLS surveys, 19 surgeons (57.6%) indicated they would use autograft (6 would use BPTB, 13 would use 4-strand semitendinosus), and 14 (42.4%) would use allograft (7 would use BPTB, 5 would use Achilles, and 2 would use tibialis anterior) in 35-year-old recreational athletes.

Twenty-one surgeons (44.7%) were drilling the femoral tunnel through a transtibial portal, 36.2% through an antero-medial portal, and 12.8% using a 2-incision technique. All surgeons indicated they were using a single-bundle technique in ACL reconstruction. Thirty-three surgeons (70.2%) did not recommend a brace for their elite athletes on RTS. Olympic team surgeons had the highest rate of brace wear in RTS (50%, both skiers and snowboarders); NHL and MLS surgeons had significantly lower rates (25% and 15.4%, respectively) (Table 3).

Twenty (60.6%) of the NHL and MLS surgeons recom-

**Table 1. Demographic Data for Team Physicians**

Organization	Mean (SD) Number of:	
	Years as Team Physician	Anterior Cruciate Ligament Reconstructions Performed in 2012
National Hockey League	7.73 (5.33)	101 (51)
Major League Soccer	6.77 (6.64)	78 (38)
US Olympic/World Cup Ski/Snowboard	1.14 (0.36)	110 (105)

**Table 2. Graft Choices by Sport in Elite, 25-Year-Old, and 35-Year-Old Athletes**

Athletes	Autograft			Allograft			
	Bone-Patellar Tendon-Bone	4-Strand Semitendinosus	Quadriceps	4-Strand Semitendinosus	Bone-Patellar Tendon-Bone	Achilles	Tibialis Anterior
<b>Elite</b>							
NHL	13	6	0	1	0	—	—
MLS	11	1	0	1	0	—	—
Olympic	9	0	2	2	1	—	—
<b>25-year-old</b>							
NHL	11	8	0	1	0	—	—
MLS	8	4	0	0	1	—	—
Olympic	6	1	2	3	2	—	—
<b>35-year-old</b>							
NHL	5	8	0	0	2	3	2
MLS	1	5	0	0	5	2	0

Abbreviations: MLS, Major League Soccer; NHL, National Hockey League; Olympic, US Olympic/World Cup Ski/Snowboard.

mended waiting at least 6 months before RTS; 2 (6.1%) recommended waiting at least 9 months; no surgeon recommended waiting at least 12 months; and the others did not have a specific time frame for RTS. Twenty-seven surgeons (81.8%) recommended RTS after an athlete passed a series of RTS tests (eg, Vail, single-leg hop). Nineteen surgeons (57.6%) recommended waiting until the athlete had full range of motion, no pain, full strength, and subjective stability in the knee. Physicians could choose more than one answer for the previous question, allowing for a total percentage higher than 100%.

## Discussion

The goal of this study was to determine how NHL, MLS, and Olympic team orthopedic surgeons manage ACL tears in elite and recreational athletes. Our study hypotheses were confirmed, as 70.2% of those surveyed used BPTB autograft for elite athletes, 100% used the single-bundle technique, 70.2% did not require a brace on RTS, 81.8% recommended RTS after the athlete passed a series of RTS tests (eg, Vail, single-leg hop), and 60.6% waited at least 6 months after surgery.

As soccer and skiing are the top 2 sports in which participants sustain ACL tears, it is necessary to report how surgeons obtain successful results in these patient populations.<sup>6</sup> Using the US and Norwegian ACL reconstruction registries, Granan

and colleagues<sup>6</sup> found that, over a 7-year period, 5760 ACL tears occurred during soccer, and 2030 occurred during skiing. The scope of ACL injuries is broad, and treatment patterns must be elucidated. Although most surgeons do not treat elite athletes, many high school and college athletes compete at very high levels. Therefore, replicating the methods of the surgeons who treat elite athletes may be warranted.

In our survey, autograft (89.4%), particularly BPTB autograft (70.2%), was the most common graft choice for elite athletes. The rate of allograft use (42.4%) was higher for 35-year-old recreational athletes. As BPTB autograft produces reliable long-term results, this graft type is a reasonable choice.<sup>7</sup> However, only 18% of our surveyed orthopedic surgeons indicated they would use BPTB autograft in older, recreational athletes. This stark difference is likely related to the more than 40% long-term side effects of anterior knee pain and graft harvest site morbidity with BPTB autograft as opposed to allograft and other types of autograft.<sup>8,9</sup> Younger patients may be more willing to accept some anterior knee pain to ensure bone-to-bone healing with BPTB autograft. This shift in graft choice may also reflect the desire to minimize skin incisions and their resulting scars, especially in female recreational athletes.

In a meta-analysis of more than 5000 patients, Kraeutler and colleagues<sup>7</sup> found that BPTB autograft outperformed al-

**Table 3. Femoral Tunnel Drilling, Bundle Technique, and Return-to-Sport Criteria for Elite Athletes**

Organization	Femoral Tunnel Drilling					
	Transtibial	Anteromedial	2-Incision	Other <sup>a</sup>		
NHL	9	6	4	1		
MLS	7	5	1	0		
Olympic	5	6	1	2		
		Bundle Technique				
		Single	Double			
NHL		20	0			
MLS		13	0			
Olympic		14	0			
		Brace Recommended for Elites' Return to Sports				
		Yes	No			
NHL		5	15			
MLS		2	11			
Olympic		7	7			
		Criteria for Elites' Return to Sports				
		≥6 mo	≥9 mo	≥12 mo	Tests <sup>b</sup>	Functional <sup>c</sup>
NHL		11	1	0	15	10
MLS		9	1	0	12	7

Abbreviations: MLS, Major League Soccer; NHL, National Hockey League; Olympic, US Olympic/World Cup Ski/Snowboard.

<sup>a</sup>One NHL surgeon did not specify; 2 Olympic surgeons used a flip cutter.

<sup>b</sup>Included Vail and single-leg hop.

<sup>c</sup>No pain, normal range of motion, full strength, subjective stability.

lograft according to several knee scores, including Lysholm and Tegner, and had a lower re-rupture rate (4.3% vs 12.7%). However, despite the superior performance of BPTB autograft, graft choice cannot overcome surgeon error in graft placement.<sup>10</sup> BPTB autograft appears to remain the gold standard for ACL reconstruction for many reasons, including low failure rates and decreased costs.<sup>11</sup> Recently, investigators have tried to challenge the superiority of BPTB autograft. In a retrospective case-control study, Mascarenhas and colleagues<sup>12</sup> found that hamstring autograft afforded patients better extension and higher subjective outcome scores. Bourke and colleagues<sup>13</sup> found a higher rate of contralateral ACL rupture in patients treated with BPTB autograft compared with hamstring autograft.

According to this survey, 44.7% of surgeons indicated they drilled the femoral tunnel through a transtibial portal, 36.2% used an anteromedial portal, and 12.8% used the 2-incision technique. These methods were recently evaluated to determine if any is superior to the others, but the study results were not definitive.<sup>14</sup> Franceschi and colleagues<sup>15</sup> found improved rotational and anterior stability of the knee with use of an anteromedial approach, but their findings were not clinically or functionally significant. Wang and colleagues<sup>16</sup> found an extension loss in the late-stance phase of gait with the anteromedial approach; the transtibial approach was correlated with inferior anterior-posterior stability during the stance phase of gait. Therefore, our results parallel those in the current literature in that the surveyed population is split on which technique to use and likely bases its practice on comfort level and residency/fellowship training.

### Limitations

This study had several limitations. First, it provided level V evidence of team physicians in 3 major sports. Although some of these physicians were also treating athletes in other sports, our survey targeted NHL, MLS, and Olympic athletes. It did not address all ages and both sexes—which is significant, given the higher rate of ACL tears in females. All NHL and MLS players are male, and there was a high rate of BPTB graft use in these sports. However, recreational athletes include both males and females, and the fact that some surgeons would choose a hamstring graft for a female for cosmetic reasons must not be overlooked. Conversely, that there was no difference in the number of BPTB autografts chosen between NHL and MLS surgeons versus Olympic surgeons, where females are included (all chose about 60% BPTB autografts for their elite athletes), disputes this limitation. Our survey response rate was 50%. Other studies have had similar rates in relation to ACL practices,<sup>17</sup> especially elite team physicians' practices,<sup>5</sup> and recent literature has confirmed that lower response rates in surveys did not alter results and may in fact have improved results.<sup>18,19</sup> This percentage could be falsely low if some of our email addresses were incorrect. This rate also raises the possibility of selection bias, as surgeons who routinely used allograft in their athlete population may not have wanted to admit this. It is possible that some NHL, MLS, and Olympic athletes were treated by surgeons not included in this survey

(in some cases, a non-team surgeon may have performed the athlete's surgery). This survey did not address concomitant knee pathology or cover all possible technique variables.

### Conclusion

Most of the NHL, MLS, and Olympic team orthopedic surgeons who were surveyed perform their ACL reconstructions using BPTB autograft, using a single-bundle technique, through a transtibial portal, and do not require bracing for their athletes returning to sport. Most required their athletes to complete a series of RTS tests before resuming competitive play.

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*This paper will be judged for the Resident Writer's Award.*

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