PODCAST 5-in-5

Lateral Ligament Reconstruction With Hamstring Graft for Ankle Instability

Outcomes for Primary and Revision Cases

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Background: Optimal treatment for patients with severe ankle instability or failed previous ankle stabilization is not well defined, and newer techniques have limited presence in the literature.

Purpose/Hypothesis: The purpose of this study was to evaluate clinical and radiographic outcomes after modified anatomic lateral ligament reconstruction using hamstring auto- or allograft in primary cases versus revision cases. We hypothesized that patients undergoing a revision procedure would demonstrate inferior patient-reported and radiographic outcomes.

Study Design: Cohort study; Level of evidence, 3.

Methods: Patients who underwent modified anatomic lateral ligament reconstruction by a single surgeon between 2010 and 2017 were identified. Indications included failure of previous ankle stabilization or severe ankle laxity. Patients completed preoperative and minimum 1-year postoperative Foot and Ankle Outcome Score (FAOS) surveys. They also underwent pre- and postoperative stress radiographs using the Telos Stress Device.

Results: A total of 41 patients (42 ankles) were identified. The mean age was 32.1 years, and 36 patients (88%) were women. There were 25 primary procedures and 17 revision procedures. Hamstring autograft was utilized in 35 ankles and hamstring allograft in 7 ankles. A total of 34 patients (83%) provided postoperative patient-reported outcome scores at a mean of 26 months (range, 12-65 months). When comparing primary versus revision procedures, revision patients had significantly lower FAOS Pain (77.14 vs 90.66; $P = .009$), Sports (63.46 vs 82.16; $P = .008$), and Quality of Life (53.53 vs 76.70; $P = .002$) scores. In total, 34 patients (83%) had stress radiographs at a mean of 14 months (range, 3-62 months) postoperatively. Revision patients also had lower, though statistically insignificant, postoperative talar tilt measurements on average (5.73° vs 7.10°; $P = .252$), and pre- to postoperative change in talar tilt was not significantly different between groups (−4.94° vs −7.03°; $P = .415$).

Conclusion: Revision procedures had significantly lower postoperative patient-reported outcome scores and lower talar tilt compared with patients undergoing a primary procedure, although the pre- to postoperative change in the talar tilt was not significantly different between groups.

Keywords: ankle instability; lateral ligament reconstruction; hamstring graft; revision ankle stabilization; generalized ligamentous laxity

Chronic ankle instability is a common orthopaedic problem that may occur in up to 40% of patients after an acute ankle sprain.[9] In most cases, direct ligament imbrication with inferior extensor retinaculum augmentation successfully stabilizes the ankle (modified Broström-Gould procedure).[1,2,6,7,10,17] However, this procedure is thought to be insufficient for patients with generalized ligamentous laxity, high-grade ankle laxity, a heavier build, high athletic demands, underlying deformity, or failed previous ligament repair.[4,17,19,24] Ligament reconstruction, rather than repair, may provide a better alternative for these subsets of patients.[15,30]

Outcomes after nonanatomic lateral ligament reconstruction, including the Watson-Jones and Chrisman-Snook procedures, have historically been poor.[13,14,22,28,32]

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Submitted June 17, 2020; accepted March 15, 2021.

One or more of the authors has declared the following potential conflict of interest or source of funding: K.A.P. has received education support from Arthrex. M.C.D. has received consulting fees from DePuy Synthes and Extremity Medical, educational support from Gotham Surgical Solutions & Devices, and royalties from Extremity Medical. AOSSM checks author disclosures against the Open Payments Database (OPD). AOSSM has not conducted an independent investigation on the OPD and disclaims any liability or responsibility relating thereto.

The American Journal of Sports Medicine
2021;49(10):2697–2706
DOI: 10.1177/03635465211026969

Studies evaluating patient outcomes have reported the development of peroneal muscle fatigue, subtalar stiffness and osteoarthritis, calf atrophy, persistent instability, and low functional outcome scores.[3,8,16,22,27,28] Thus, when ligament reconstruction is necessary, anatomic lateral ligament reconstruction is generally preferred. Recent studies have demonstrated good patient-reported outcomes and radiographic stability after reconstruction with hamstring autograft,[20,29,33] although few have evaluated the procedure in a revision setting for patients with a failed index procedure. Two case series have been published that describe lateral ligament reconstruction with a hamstring graft in a revision setting, although clinical and radiographic comparisons between primary and revision procedures are not described in detail.[18,33]

To our knowledge, no study to date has compared outcomes after primary versus revision lateral ligament reconstruction. In this study, our primary aim was to report clinical and radiographic outcomes after modified anatomic lateral ligament reconstruction using hamstring auto- or allograft in patients with severe ankle instability (primary cases) or failed previous ankle stabilization (revision cases). We hypothesized that patients undergoing a revision procedure would demonstrate inferior patient-reported and radiographic outcomes. We also sought to compare outcomes for patients who underwent reconstruction with hamstring autograft versus allograft and for patients presenting with or without generalized ligamentous laxity. We hypothesized that autografts from patients with generalized ligamentous laxity would be more likely to stretch, resulting in larger postoperative radiographic measurements for these patients.

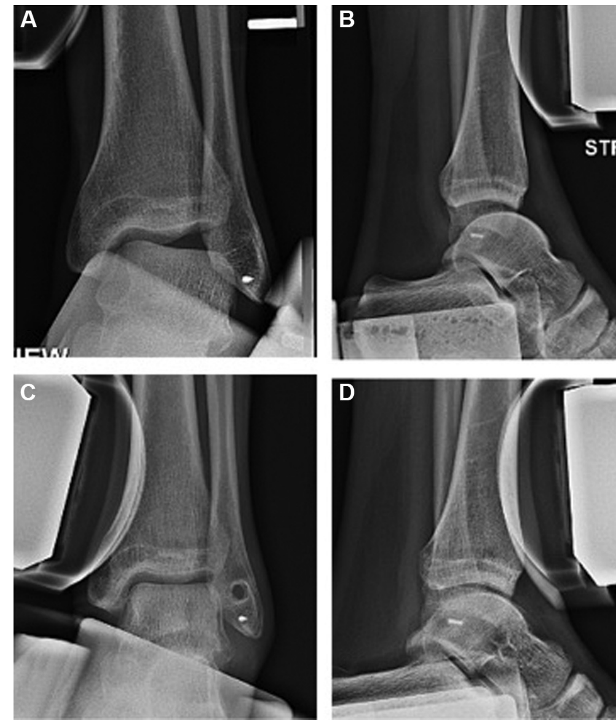

Figure 1. Example of pre- and postoperative stress radiographs of a patient who underwent lateral ligament reconstruction after a failed primary ligament repair procedure. Preoperative radiographs demonstrate increased talar tilt and anterior drawer, which are substantially improved at 9 months postoperatively. (A) Preoperative anteroposterior stress radiograph. (B) Preoperative lateral stress radiograph. (C) Postoperative anteroposterior stress radiograph. (D) Postoperative lateral stress radiograph.

METHODS

Study Population and Design

Approval was obtained from our institutional review board–approved research steering committee. Patients who underwent lateral ligament reconstruction with hamstring auto- or allograft by the senior author (M.C.D.) between 2010 and 2017 were identified. Patients with ankle instability who did not undergo hamstring reconstruction were excluded. The author's indications for lateral ligament reconstruction included severe lateral ligament instability, defined by a talar tilt angle $>20^\circ$ on stress radiographs or anterior drawer measurement of >15 mm, generalized ligamentous laxity, or failed previous ligament repair. Before undergoing lateral ligament reconstruction at our institution, all patients had failed nonoperative management including physical therapy and restricted weightbearing. The physical therapy program included peroneal strengthening, ankle bracing, and proprioceptive training. Patients whose symptoms did not improve with 3 months of therapy were considered for operative treatment.

Generalized ligamentous laxity was categorized by a Beighton score of ≥ 5.[26] Hamstring autograft was recommended to all patients; however, several patients preferred allograft reconstruction for personal reasons, such as a desire to avoid a second incision.

Chart review was utilized to evaluate for concurrent ankle pathologies addressed at the time of ankle stabilization, including treatment of peroneal tendon pathology in 7 cases (16.7%).

Functional and Radiographic Outcomes

A thorough chart review was performed for each patient to determine clinical outcomes, including any complications, complaints, failures, or need for revision. Complications were evaluated based on the last available office visit follow-up, which was available for all 42 ankles. Patient-reported functional outcomes were also collected in the form of Foot and Ankle Outcome Score (FAOS) values, which were obtained preoperatively and at a minimum of 1 year postoperatively. FAOS has been validated for patient outcomes after ankle reconstruction and was administered pre- and postoperatively per departmental standards during the study period.[23] A total of 34 patients (83%) provided postoperative patient-reported outcome scores at a mean of 26 months (range, 12-65 months).

Figure 2. A 5-cm incision is marked out over the distal fibula and a 1-cm incision is indicated over the calcaneal tuberosity in line with the fibula.

Figure 3. After the anterior talofibular ligament and calcaneofibular ligament are taken down off the distal fibula, the graft is fixed in the calcaneus using an interference screw.

In addition to standing ankle radiographs, stress radiographs were performed by trained technicians both preoperatively and at a minimum of 3 months postoperatively using the Telos device (METAX GmbH) with 170 N of force (Figure 1). Talar tilt and anterior drawer measurements were independently performed by 2 investigators (S.K.E., O.B.H.) for both preoperative and postoperative stress radiographs. A total of 34 patients (83%) had stress radiographs at a mean of 14 months (range, 3-62 months) postoperatively.

Surgical Technique

Patients were initially positioned supine with a large bolster under the ipsilateral ischial tuberosity. The ankle was placed in traction and diagnostic arthroscopy was performed under

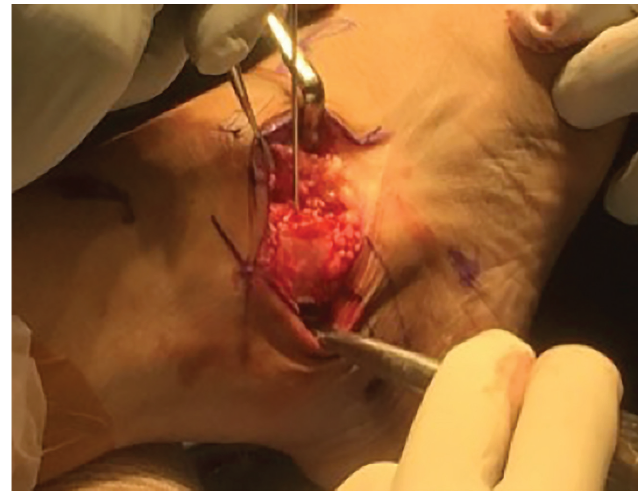

Figure 4. A Cobb elevator protects the peroneal tendons through a window in the peroneal retinaculum. A fibular tunnel is drilled over a guidewire from anterior to posterior.

a thigh tourniquet. Any intra-articular pathology was addressed, and the traction setup was removed.

For hamstring autograft cases, the autograft was harvested through a 3-cm incision on the proximal tibia. Visual inspection of the gracilis and semitendinosus tendons was performed. The decision of which tendon to take was made based on the surgeon's preference. The ideal graft size was considered to be $\geq$4 mm in diameter. For some patients, particularly young women, the gracilis diameter was $\leq$3.5 mm, and thus the semitendinosus tendon was harvested. A layered closure was then performed, which included closing the sartorial fascia. The graft was then prepared on a separate table. Any attached muscle was removed and the graft was tubularized using absorbable sutures. The graft was folded over, if necessary, with a goal length of 15 cm and thickness of 4 to 5 mm. A 5-cm curvilinear incision was made over the center of the distal fibula extending toward the fourth metatarsal (Figure 2). The anterior talofibular ligament (ATFL) and calcaneofibular ligament (CFL) were incised off the distal fibula; the peroneal tendons were protected posteriorly. A curette was used to remove the periosteum off the distal fibula and to create a bleeding bony surface for healing. Next, a 1-cm incision was made in line with and distal to the fibula over the calcaneus near the CFL insertion. Blunt dissection was carried down to the calcaneal tuberosity, taking care to avoid the peroneal tendons and sural nerve. Fluoroscopy was used to confirm the position of the tunnel in the calcaneal tuberosity at the CFL insertion. The graft was then fixed in the calcaneus with an interference screw typically measuring 4.5 mm $\times$ 15 mm (Figure 3).

The screw size was usually either the same size as the tunnel or 0.25 to 0.5 mm greater to allow for an appropriate friction fit with the biotenodesis screw. A window was made in the peroneal retinaculum posterior to the fibula and a tunnel was drilled over a guidewire from anterior to posterior in the distal fibula, taking care to protect the

Figure 5. Intraoperative fluoroscopy confirms appropriate location of the guidewire in the anterior aspect of the lateral process of the talus.

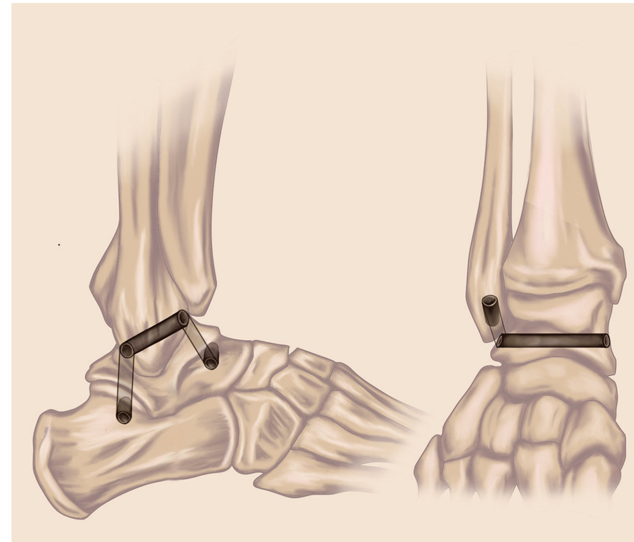

Figure 6. Lateral and anterior illustrations of the graft construct detailing the position of the fibular and talar tunnels.

tendons from the drill (Figure 4). The exit site of this tunnel was proximal and posterior to the anatomic attachment of the CFL to ensure that there was an adequate bone bridge to avoid a fracture of the distal fibula. The graft was then passed under the soft tissue envelope deep to the peroneal tendons and from posterior to anterior in the fibular tunnel. A guidewire was placed in the talar neck, with placement confirmed on fluoroscopy, and a tunnel was drilled exiting between the tibialis anterior tendon and posterior tibial tendon (Figure 5).

The graft was then passed through a soft tissue tunnel beneath the ATFL and through the tunnel in the talus exiting medially (Figure 6). A small incision was placed medially over the talar tunnel to allow the graft to pull through the skin. While the graft was tensioned and the ankle held in eversion and posterior translation, interference screws were placed in the fibular and talar tunnels. The native ATFL and CFL were then repaired using 2-0 permanent braided suture augmented with the inferior extensor retinaculum. A layered closure was performed, and the extremity was placed in a short-leg plaster splint.

The postoperative protocol included splint immobilization with no weightbearing for 2 weeks, and aspirin for venous thromboembolism prophylaxis. At 2 weeks postoperatively, the patient was transitioned to a boot with gentle range of motion exercises, including knee exercises for patients who had undergone hamstring harvest. Partial weightbearing was initiated at 4 weeks with subsequent progression to full weightbearing. Standardized physical therapy was initiated at 6 weeks postoperatively. Patients typically returned to light jogging at 3 months and to all sports at 6 months postoperatively.

Statistical Analysis

Variables of interest in this study were summarized using means and ranges. Normality of the data was assessed using the Shapiro-Wilk test. Because of evidence of nonnormality in the data based on plotting of the distributions, pre- to postoperative changes in functional outcome scores and radiographic measurements were evaluated using the Wilcoxon signed-rank test. Subgroup and demographic comparisons were performed using Wilcoxon rank-sum tests. The subgroup analyses included comparisons for primary versus revision cases, autograft versus allograft procedures, generalized ligamentous laxity versus no generalized ligamentous laxity cases, and concurrent ankle procedures. We also compared outcomes for patients who received an allograft versus those with generalized ligamentous laxity who received an autograft. Intraclass correlation coefficients were calculated to determine interrater reliability of radiographic measurements. Analyses were run using a significance level of .05.

RESULTS

Full Cohort

In total, 41 patients (42 ankles) were identified that fit inclusion criteria (Figure 7). The mean age was 32.1 years (range, 14.5-61.5 years); there were 36 female (88%) and 5 male (12%) patients. The mean body mass index was 26 (range, 18.3-41.2). There were 25 primary cases (59.5%) and 17 revision cases (40.5%). For the 17 patients presenting after a failed index procedure, the method of ligament repair in the index procedure was evaluated using preoperative radiographs and operative reports. Ten patients had a previous modified Broström-Gould procedure, and

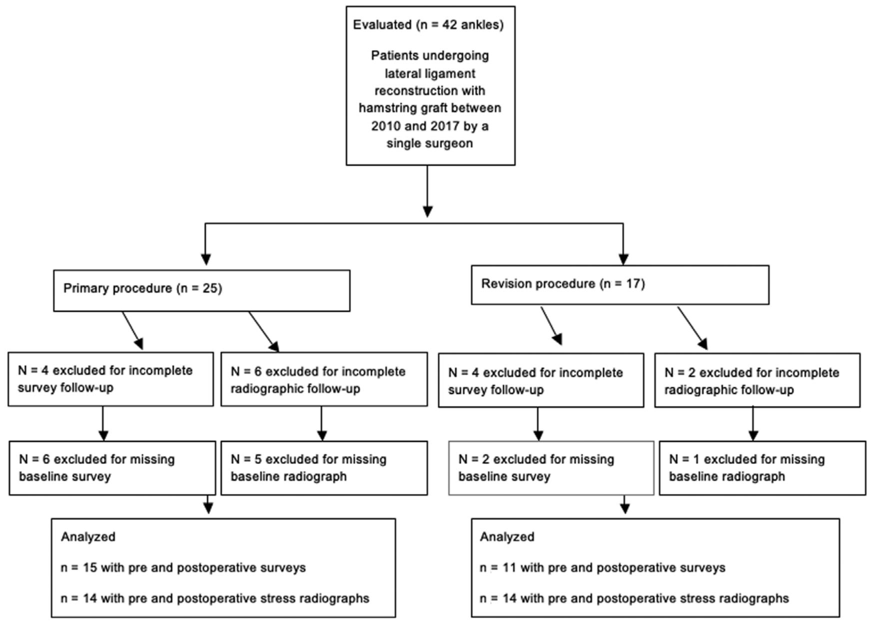

Figure 7. The number of patients evaluated and with complete follow-up data for each group.

previous ligament repair included the use of 2 anchors for 2 patients, 1 anchor in 3 patients, and no anchors in the remaining patients. One patient had a failed Chrisman-Snook procedure, and 1 had failed previous anatomic reconstruction 10 years previously. For the 25 primary cases, indications for ligament reconstruction included talar tilt $>20^\circ$ in 11 cases (26.2%) and generalized ligamentous laxity in 13 cases (31%). Surgical indication for the final primary case included severe chronic instability with multiple dislocations. A total of 35 ankles (83.3%) underwent ligament reconstruction using hamstring autograft while 7 ankles (16.7%) underwent hamstring allograft reconstruction.

All but 1 patient underwent ankle arthroscopy at the time of surgery, and 15 patients (36.6%) underwent microfracture of osteochondral lesions at the time of surgery. There were 10 medial talar dome lesions, 4 lateral talar dome lesions, 2 distal fibular lesions, 1 medial malleolar lesion, and 1 tibial plafond lesion; several ankles had more than 1 cartilage lesion. Four patients had mild ankle osteoarthritis preoperatively. A summary of concurrent procedures is presented in Table 1.

When evaluating all patients with pre- and postoperative FAOS scores, significant pre- to postoperative improvement in each FAOS category was detected ($P < .01$) (Table 2). For all categories, these average changes exceeded previously established values for minimally important change in FAOS.[25]

When evaluating all patients with pre- and postoperative stress radiographs, both anterior drawer and talar tilt measurements improved on average (Table 3). Interrater reliability for radiographic measurements was found to be excellent with an intraclass correlation coefficient of at least 0.86 for each comparison.

TABLE 1
Concurrent Procedures Performed at the Time of Lateral Ligament Reconstruction

Procedure Performed	No. of Patients
Microfracture for talar osteochondral lesion	22
Microfracture for fibular osteochondral lesion	4
Tenolysis of peroneal tendon	8
Modified Broström-Gould	8
Removal of loose body	4

Subgroup Comparisons

For each subgroup comparison, demographic information and average time to clinical and radiographic follow-up are presented in Table 4.

Primary Versus Revision Procedures

For patients undergoing revision versus primary procedures, preoperative FAOS Pain scores were not significantly different. Postoperatively, the revision group had lower Pain, Activities of Daily Living (ADL), Sports, Quality of Life (QoL), and total FAOS scores compared with the primary procedure group, although there were no significant differences between groups in pre- to postoperative change for any FAOS category (Table 5).

When comparing patients undergoing revision versus primary procedures, there were no significant differences in preoperative anterior drawer or talar tilt measurements between groups (Table 6).

TABLE 2
Patient-Reported Functional Outcomes Improved Significantly for All Patients Undergoing Lateral Ligament Reconstruction As Shown With Pre- and Postoperative FAOS (n = 26)[a]

	Preoperative	Postoperative	Pre- to Postoperative Change	*P* Value
FAOS Pain	55.44 (22.22 to 86.11)	84.94 (41.67 to 100)	+ 33.76 (−22.22 to + 88.89)	**<.01**
FAOS Symptoms	58.24 (28.57 to 92.86)	76.92 (32.14 to 100)	+ 18.68 (−7.15 to + 42.86)	**<.01**
FAOS ADL	74.66 (39.71 to 100)	91.97 (52.94 to 100)	+ 25.93 (−20.59 to + 100)	**<.01**
FAOS Sports	35.63 (0 to 90)	75.00 (5 to 100)	+ 40.54 (−10 to + 100)	**<.01**
FAOS QoL	21.67 (0 to 50)	68.11 (18.75 to 100)	+ 47.27 (+ 4.17 to + 93.75)	**<.01**
FAOS Total	48.55 (29.61 to 81.81)	79.39 (41.53 to 100)	+ 33.24 (−6.73 to + 73.46)	**<.01**

[a]Data are reported as mean (range). Values in boldface indicate statistical significance. ADL, Activities of Daily Living; FAOS, Foot and Ankle Outcome Score; QoL, quality of life.

TABLE 3
Radiographic Results Improved Significantly for All Patients Undergoing Lateral Ligament Reconstruction As Shown With Pre- and Postoperative Stress Radiographs (n = 28)[a]

	Preoperative	Postoperative	Pre- to Postoperative Change	*P* Value
Anterior drawer, mm	9.06 (4.05 to 14.85)	6.71 (3.90 to 9.85)	−2.32 (−10.65 to + 2.60)	**.007**
Talar tilt, deg	12.40 (1.85 to 32.80)	6.42 (2.15- to 13.55)	−5.98 (−26.45 to + 8.40)	**<.001**

[a]Data are reported as mean (range). Values in boldface indicate statistical significance.

Hamstring Autograft Versus Allograft

For patients undergoing hamstring autograft versus those undergoing hamstring allograft, there were no significant differences between groups for any FAOS subscales, preoperatively, postoperatively, or in pre- to postoperative change (see Appendix Table A1, available in the online version of this article).

For patients undergoing hamstring autograft versus allograft, there were no significant differences in preoperative anterior drawer or talar tilt measurements between groups. Postoperatively, the autograft group had a smaller talar tilt on average (6.15 mm vs 9.74 mm; *P* = .013), although the pre- to postoperative change in talar tilt was not significantly different between groups (Appendix Table A2, available online).

Generalized Ligamentous Laxity

For patients presenting with generalized ligamentous laxity versus those who did not, there were no significant differences between groups for any FAOS subscales, preoperatively, postoperatively, or in pre- to postoperative change (Appendix Table A3, available online).

When comparing patients with and without generalized ligamentous laxity, preoperative talar tilt measurements were significantly higher for the nongeneralized ligamentous laxity group (14.65 mm vs 8.34 mm; *P* = .036). Postoperatively, there were no significant differences between groups, although the pre- to postoperative change in talar tilt was significantly greater for the nongeneralized ligamentous laxity group (−8.08 mm vs −2.21 mm; *P* = .021) (Appendix Table A4, available online).

A comparison was also made between the 7 patients who received an allograft, 2 with generalized ligamentous laxity, and the 12 patients with generalized ligamentous laxity who received an autograft. No significant differences were observed between these 2 groups in survey outcomes or radiographic measurements, although patients in the allograft group tended to have higher preoperative and postoperative talar tilt (9.25° vs 6.65°). Preoperative and postoperative anterior drawer measurements were similar between groups.

Other Concurrent Procedures

No significant differences were observed for preoperative or postoperative FAOS scores when comparing patients who underwent concurrent procedures for cartilage injury or peroneal pathology versus those who did not undergo a concurrent procedure, with the exception of preoperative

TABLE 4
Demographic and Average Time to Survey and Radiographic Follow-Up for Each of the Subgroup Comparisons[a]

	Revision Cases	Primary Cases	*P* Value
Age, y	33.63 (20-57)	30.98 (14-62)	.210
BMI	25.78 (19.1-41.2)	26.09 (18.3-36.9)	.927
Time to survey follow-up, months	18.96 (12-43; n = 11)	30.25 (12-65; n = 15)	**.020**
Time to radiographic follow-up, months	14.00 (5-44; n = 14)	16.49 (4-45; n = 14)	.614
	Autograft Cases	Allograft Cases	*P* Value
Age, y	31.50 (14-62)	34.81 (21-51)	.543
BMI	26.44 (18.3-41.2)	22.40 (21.9-22.9)	.418
Time to survey follow-up, months	25.25 (12-63; n = 20)	29.11 (12-65; n = 6)	.547
Time to radiographic follow-up, months	15.27 (5-45; n = 22)	15.05 (4-34; n = 6)	.547
	Generalized Ligamentous Laxity Cases (n = 14)	No Generalized Ligamentous Laxity Cases (n = 28)	*P* Value
Age, y	25.14 (14-61)	35.51 (20-62)	**.012**
BMI	26.07 (18.3-36.9)	25.89 (19.1-41.2)	.954
Time to survey follow-up, months	32.63 (12-65; n = 10)	22.28 (12-51; n = 16)	**.037**
Time to radiographic follow-up, months	19.77 (6-45; n = 10)	12.73 (4-44; n = 18)	.165

[a]Data are reported as mean (range) unless otherwise indicated. Each partial n represents the number of surveys or stress radiographs available for each subgroup comparison. Values in boldface indicate statistical significance. BMI, body mass index.

FAOS ADL score, which was lower in the concurrent procedure group (83 vs 66; *P* = .036). Patients with cartilage lesions or peroneal pathology did not demonstrate any differences in radiographic laxity compared with patients without these injuries.

Complications

In total, 14 patients (34.1%) experienced a postoperative complication. There were 4 cases (9.8%) of minor wound edge necrosis requiring local wound care. Two patients (4.9%) had persistent nerve dysfunction, including 1 with sural nerve dysesthesias and 1 with numbness related to the infrapatellar branch of the saphenous nerve opposite the hamstring autograft harvest site. One patient (2.4%) developed a deep venous thrombosis at 8 weeks postoperatively. The remaining 7 patients (17.1%) reported persistent postoperative pain or stiffness. There were no deep infections or failures during the study period, although 1 patient returned to the operating room for removal of an interference screw at 2 years postoperatively. Revision patients experienced 57% of total complications, with 43% of complications arising in primary patients (*P* = .12). Of note, there was no patient-reported persistent pain or functional deficit at the site of the hamstring harvest at the latest clinical follow-up.

DISCUSSION

The primary aim of this study was to compare the functional and radiographic outcomes of patients undergoing lateral ligament reconstruction with a hamstring auto- or allograft in a primary setting of severe ankle instability versus a revision procedure. When analyzing averages across all patients, we found that lateral ligament reconstruction was successful in stabilization of the ankle, as evidenced by significant improvement in pre- to postoperative outcomes across all FAOS survey categories and radiographic measurements. This result indicates the general efficacy of the procedure in both revision and primary cases. To our knowledge, no studies of lateral ligament reconstruction using a hamstring graft have compared outcomes between primary and revision cases.

Our analysis of various subgroups revealed some distinct differences. Revision patients had significantly lower postoperative FAOS scores in several categories, including Pain, Sports, QoL, and total FAOS. However, because preoperative scores for revision patients also tended to be lower, there was no significant difference in pre- to postoperative change in these categories when comparing revision versus primary patients. The primary cases tended to have greater talar tilt, both pre- and postoperatively, although these differences were not significant. The tendency toward greater preoperative tilt in the primary cases is consistent with the senior surgeon's indications for primary reconstruction, including only cases of severe ankle instability, which is characterized by an especially large talar tilt measurement, among other criteria. Revision patients, however, were eligible for reconstruction with a smaller preoperative talar tilt on average because they had failed a previous procedure.

When comparing patients who received auto- and allografts, no differences were detected in survey scores. Allograft patients had significantly greater postoperative talar tilt, but their preoperative talar tilt also tended to be larger, and thus a significant difference between groups was not detected for pre- to postoperative change. Our findings are consistent with previous findings from Xu et al,[33] who compared autografts and allografts and observed no

TABLE 5
Pre- and Postoperative FAOS Scores for Primary and Revision Cases[a]

		Revision	Primary	*P* Value
FAOS Pain	Preoperative	47.50 (22.22 to 69.44)	61.11 (38.89 to 91.67)	.070
	Postoperative	75.51 (41.67 to 97.22)	91.85 (66.67 to 100)	**.010**
	Pre- to postoperative change	+ 32.33 (−22.22 to + 88.89)	+ 34.81 (+ 8.34 to + 83.33)	.804
FAOS Symptoms	Preoperative	51.95 (32.14 to 75.00)	62.86 (28.57 to 92.86)	.128
	Postoperative	70.78 (32.14 to 85.71)	81.43 (60.71 to 100)	.082
	Pre- to postoperative change	+ 18.83 (−7.15 to + 42.85)	+ 18.57 (−3.58 to + 42.86)	.966
FAOS ADL	Preoperative	71.38 (48.33 to 100)	76.77 (39.71 to 100)	.521
	Postoperative	85.56 (52.94 to 100)	96.67 (85.30 to 100)	**.018**
	Pre- to postoperative change	+ 27.16 (−20.59 to + 100)	+ 25.02 (0 to + 100)	.870
FAOS Sports	Preoperative	34.44 (0 to 80)	36.33 (0 to 90)	.853
	Postoperative	62.73 (5 to 95)	84.00 (60 to 100)	**.015**
	Pre- to postoperative change	+ 34.55 (−10 to + 95)	+ 44.93 (0 to + 100)	.377
FAOS QoL	Preoperative	18.33 (0 to 37.5)	23.89 (0 to 50)	.383
	Postoperative	55.30 (18.75 to 93.75)	77.50 (37.5 to 100)	**.017**
	Pre- to postoperative change	+ 38.64 (+ 4.17 to + 93.75)	+ 53.61 (+ 20.83 to + 91.67)	.109
FAOS Total	Preoperative	44.52 (29.61 to 60.92)	51.50 (31.43 to 81.81)	.225
	Postoperative	69.98 (41.53 to 94.34)	86.29 (69.65 to 100)	**.010**
	Pre- to postoperative change	+ 30.30 (−6.73 to + 73.46)	+ 35.39 (+ 11.43 to + 66.90)	.507

[a]Data are reported as mean (range). Values in boldface indicate statistical significance. In total, 26 patients had pre- and postoperative FAOS scores, 11 revision patients and 15 primary procedure patients. Patients undergoing a revision procedure has lower Pain, ADL, Sports, QoL, and Total FAOS scores compared with the patients undergoing a primary procedure. There were no significant differences in pre- to postoperative change in FAOS for any category. ADL, Activities of Daily Living; FAOS, Foot and Ankle Outcome Score; QoL, Quality of Life.

appreciable differences. Comparing patients with and without generalized ligamentous laxity similarly did not reveal significant differences. Survey outcomes were similar between groups, although patients without ligamentous laxity had a significantly larger reduction in talar tilt when comparing pre- and postoperative measurements. However, this group had a much higher mean talar tilt at baseline, likely because generalized ligamentous laxity was included as an indication for reconstruction, even in the absence of high talar tilt or anterior drawer measurements on preoperative stress radiographs. Of note, the allograft and generalized ligamentous laxity groups were small, which limits the power of these comparisons.

The successful outcomes observed in both autograft and allograft reconstructions are similar to those seen in previous studies. Studies evaluating autografts have used different outcome surveys, including American Orthopedic Foot & Ankle Score (AOFAS) or visual analog pain scale, so we are unable to compare results directly.[11,21,31] Nonetheless, in our cohort, patients undergoing hamstring autograft demonstrated high postoperative functional outcome scores and significant improvement in pre- to postoperative scores. Survey results from the allograft literature have shown similar levels of success, although again we are unable to compare directly because the existing literature reports mainly AOFAS and other survey scores.[4,10,12,18,34] One study that utilized FAOS scores reported postoperative averages very similar to those observed in the present study.[5]

Studies evaluating both autografts and allografts have also reported successful outcomes with respect to radiographic stability, although the methods of stress testing vary in the existing literature. Studies using the Telos

TABLE 6
Pre- and Postoperative Stress Radiographs for Primary and Revision Cases[a]

		Revision	Primary	*P* Value
Anterior drawer, mm	Preoperative	9.10 (4.45 to 14.85)	9.02 (4.05 to 14.55)	.945
	Postoperative	6.39 (3.9 to 9.2)	7.03 (4.40 to 9.85)	.251
	Pre- to postoperative change	−2.73 (−10.65 to +1.5)	−1.88 (−7.45 to +2.60)	.501
Talar tilt, deg	Preoperative	10.67 (3.85 to 20.0)	14.13 (1.85 to 32.8)	.245
	Postoperative	5.73 (2.9 to 9.5)	7.10 (2.15 to 13.55)	.252
	Pre- to postoperative change	−4.94 (−11.0 to +0.1)	−7.03 (−26.45 to +8.4)	.415

[a]Data are reported as mean (range). In total, 28 patients had pre- and postoperative stress radiographs, 14 revision patients and 14 primary procedure patients. No significant differences were observed between groups.

device, the device used in the present study, reported similar or slightly smaller values for postoperative talar tilt and anterior drawer.[4,12,31,33,34] Average preoperative measurements were slightly more variable and are not always reported in the existing literature. Of note, several studies reported the Telos stress test with a 150 N load, while stress radiographs at our institution are conducted with a load of 170 N.[4,12,31,33] Studies comparing autograft and allograft procedures report similar ranges of postoperative talar tilt and anterior drawer, which is consistent with our finding of no significant difference in radiographic stability between these groups.[33]

When we compared outcomes for patients who received an allograft and patients with generalized ligamentous laxity who received an autograft, we did not detect any significant differences in survey or radiographic outcomes, although sample sizes were small. This was contrary to our hypothesis that autografts from patients with generalized ligamentous laxity might stretch out more. This result suggests that such patients are good candidates for treatment with an autograft, although larger sample sizes will be needed to confirm this finding.

This study has several limitations. First, the retrospective nature and lack of a control group are inherent limitations in the study design. Our subgroup comparisons are also limited by small sample sizes; thus, any lack of detectable differences between subgroups may be the result of inadequate sample sizes and should be viewed critically. Further, we evaluated only patients undergoing lateral ligament reconstruction with hamstring auto- or allograft, although studies evaluating other methods of reconstruction or comparing reconstruction with repair would be valuable, particularly if performed prospectively. Another primary limitation of this study is the influence of concurrent procedures, which potentially confounds patient outcomes. However, frequent association of ankle instability with other ankle pathologies, including articular cartilage damage or peroneal injury, is a common challenge that accompanies any study of ankle instability. The ankle stabilization technique described allows the surgeon to address all pathologies at the time of surgery, without concern for the available local tissue around the ankle for harvest. Although in the short term this procedure has shown good success in addressing persistent instability, further studies with longer-term follow-up are needed to elucidate if there is any attenuation of the tissues over time. Further refining of the indications for this procedure as an index surgery would also allow for optimization of outcomes.

With regard to follow-up time, because this is an elective procedure performed relatively infrequently by the senior author, a large range of follow-up times was introduced. This resulted in variable time to survey follow-up in our subgroup comparisons. The longer average time to follow-up for primary cases compared with revision cases is a limitation of the interpretation of our results and may have contributed to generally higher FAOS scores in the primary cases. Additionally, this study lacked a power analysis because of its retrospective nature. It is therefore possible that statistical tests failed to detect differences between groups because of lack of power, especially in the subgroup comparisons with smaller sample sizes. Finally, not all patients had outcome scores or stress testing, so there is a risk of selection bias.

CONCLUSION

The present study demonstrates that severe or recurrent lateral ankle instability can be successfully treated with ligament reconstruction using hamstring autograft or allograft, as demonstrated by radiographic, functional, and clinical outcome measures. When comparing primary and revision cases, we did not observe any significant differences in pre- to postoperative change in radiographic outcomes, although revision patients reported significantly lower postoperative functional outcome scores.

ACKNOWLEDGMENT

The authors acknowledge David Wexner for his contributions to the illustration in this article, and Rachel J.

Shakked, MD, Sydney C. Karnovsky, BA, and Taylor N. Cabe, BA, for their contributions to this article.

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