

ACL Reconstruction with Nonirradiated Soft Tissue Allografts have Favorable Outcomes in Young Female Athletes

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Purpose: Injuries to the anterior cruciate ligament (ACL) are increasing among young female athletes with rates estimated at two to eight times those experienced by male counterparts. Nonirradiated soft tissue allografts have been utilized as a reliable graft choice for ACL reconstruction in the adult population but have been used less often in younger patients due to concern for higher failure rates. Prior studies have shown that compared to nonirradiated allografts, grafts treated with irradiation and harsh chemicals have higher failure rates and most publications do not stratify outcomes between irradiated versus nonirradiated allografts in young patients. Autograft harvest-site morbidity and complications vary depending on the autograft choice and in some instances may be more common in females than males due to unique female characteristics. These risks are avoided when using allograft for ACL reconstruction. The purpose of this study was to analyze graft failure rates, contralateral and second ACL tear rates, need for second surgery, the ability to return to same high-risk pre-injury sport level and patient-reported functional outcomes in young female athlete ACL reconstructions using all soft tissue allografts (aseptic, nonirradiated Posterior Tibialis Tendon) techniques with strict rehabilitation and return to sport protocols.

Methods: Between 2006 and 2023 a consecutive series of female athletes ages 25 years or younger, with an average age of 16 years 2 months (range 12yo to 25yo), undergoing primary ACL reconstruction by the senior author with patient/parent-selected nonirradiated soft tissue allograft were retrospectively reviewed. Follow-up was limited to a minimum of 24 months. Multi-ligament knees, revision ACL reconstructions and females not participating in high-risk sports at time of injury were excluded. All allografts were from a single source and aseptically processed without irradiation or harsh chemical preparation. The same rehabilitation protocols were used in all patients including a strict return to sport objective criteria at minimum 9 months post-operative protocol. The primary outcome measure was graft failure (defined by patient reported re-tear, a subsequent ACL revision surgery and/or 2+ Lachman). Secondary outcomes included contralateral ACL tear rate, the need for a second surgery, the ability to return to pre-injury sport level and patient reported outcomes using the International Knee Documentation Committee (IKDC) subjective functional score questionnaire.

Results: A total of 122 female ACL reconstructions with nonirradiated soft-tissue allografts were identified. The final cohort included 101 primary ACL reconstructions that met inclusion criteria, including high-risk sport participation, and were available for follow-up at an average of five years, nine months (minimum 24 months). Four graft failures (3.96% failure rate) were identified. Twenty-two contralateral knee ACL tears (21.78%) were

observed, and 26 patients (25.74%) had a second ACL tear (either knee). A second surgery was required on the same knee in 15 patients (14.85%). 95.04% of patients were able to return to the same pre-injury sport level. IKDC scores were 92.23, post-operatively.

Discussion: These outcomes and complication rates in young patients receiving nonirradiated soft-tissue allografts compared favorably with other autograft options for ACL reconstruction (Figure 1). In this series of patients under age 25 years old (12yo – 25yo), a patient/ parent-choice graft selection program with appropriate education and counseling (including standard RTS postoperative rehab protocols) confirms that nonirradiated allografts for primary ACL reconstruction have favorable low failure rates (3.96% re-tear rate) compared to the published autograft failure rates of 6% - 27%. Nonirradiated allografts were favorable compared to published autograft results in secondary outcome measures including contralateral ACL tear rates (21.78% vs 7% - 18%), 2nd ACL tears in either knee (25.74% vs 20% - 42%), the need for a 2nd surgery in same knee (14.85% vs 20% - 42%), the ability to return to pre-injury sport (95.04% vs 44% - 81%) and patient-reported functional outcomes scores (IKDC: 92.23 vs 86 - 91). The importance of return to sport (RTS) objective guidelines cannot be overstated. Simple rules for decision making such as delaying RTS have been shown to be beneficial with a 50% decrease in second ACL injury for each month RTS is postponed between 6 months and 9 months. Furthermore, young athletes who return to sport before 9 months after ACL reconstruction have a new ACL injury rate that is 7 times greater than those who delay. Allografts also allow successful correction of objective measured strength deficits 2 months sooner than bone tendon bone autografts. These rules, combined with an objective battery of RTS testing should be utilized across the healthcare team to provide clear expectations for the athlete, parents, coaches, athletic trainer and/or strength and conditioning specialist for safe return to play. Advantages of allografts include less postoperative pain, less narcotic medication usage, smaller incision size, absence of a harvest site incision, improved cosmesis, shorter time away from school or work, decreased out-of-pocket costs and earlier return of range of motion, function and activities of daily living. Based on these results, nonirradiated soft tissue allografts combined with safe return to sport rehab protocols offer a reliable alternative to autografts in young female athletes and minimize the down-side morbidity and complications associated with the harvesting of autograft tissue (Figure 2).

Conclusion: With appropriate education for patient/parent graft selection and post-operative rehabilitation protocols, nonirradiated soft tissue allografts for ACL reconstruction demonstrate favorable outcomes with failure rates, contralateral and second ACL injury rates, need for second surgery, the ability to return to the same sport level and patient-reported functional outcomes in young female athletes. Based on these results, nonirradiated soft tissue allografts, combined with safe return to sport rehab protocols, offer a viable alternative to autografts and minimize the down-side donor site morbidity and complications associated with the harvesting of autograft tissue. Allografts offer the advantages of smaller incisions, less pain, less narcotic medication usage and earlier return of range of motion, function, and activities of daily living. These outcomes and complications in young female athletes receiving nonirradiated soft-tissue allografts compare favorably with the published data on other autograft options for ACL reconstruction. To our knowledge, this study is the first to assess outcomes specific to

young female athletes (<25yo) undergoing primary ACL reconstruction using nonirradiated all soft tissue allografts with a minimum of 2-year follow-up.

Figure1.

| Results | | | |
|---|---|--------------------------|-------------------|
| Outcomes of Young Females Allograft versus Autograft ACL Reconstruction | | | |
| 122 patients, 101 available | Standardized RTS Program | Graft Type | |
| Ave 16y (12-25y), 5.8y fu | | Non-irradiated Allograft | Autograft-BTB/HS* |
| Primary Outcome | Graft Failure Rate | 3.96% (n = 4/101) | 6 - 27% |
| Secondary Outcomes | Contralateral ACL Tear | 21.78% (n = 22) | 7 - 18% |
| | 2 nd ACL Tear (Either Knee) | 25.74% (n = 26) | 20 - 42% |
| | Need for Subsequent Surgery (same knee) | 14.85% (n = 15) | 20 - 42% |
| | Patient Able to Return to Pre-Injury Sport Activity Level | 95.04% | 44 - 81% |
| | Post-Operative IKDC Scores | 92.23 | 86 - 91 |
| *Comparative bone-patella tendon bone and hamstring autograft data was collected from published literature includes males and females | | | |

Figure 2.

ACL Graft Morbidity and Complications

| Graft Type | Allograft | Hamstrings | Quadriceps-soft tissue | Quadriceps-with bone | Bone-Patella tendon-Bone |
|----------------------------|-----------|------------|------------------------|----------------------|--------------------------|
| Kneecap Pain and Arthritis | | | | + | + |
| Numbness | | + | | | + |
| Quadriceps Weakness | | | + | + | + |
| Hamstring Weakness | | + | | | |
| Post-op Pain and Narcotics | ↑ | ↑↑ | ↑↑ | ↑↑↑↑ | ↑↑↑↑ |
| Patella Fracture | | | | + | + |
| Tendon Rupture | | | | | + |
| Hematoma | | + | + | + | + |
| Total Incision Size | ↑ | ↑↑ | ↑↑ | ↑↑↑↑ | ↑↑↑↑↑ |