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Clinical, Surgical, And Functional Outcomes After Ankle Ligament Surgery In Young Adults: A Retrospective Analysis.

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Abstract

Objective: To analyze the clinical, surgical, anesthetic, and functional outcomes of young adults undergoing surgical treatment for ankle ligament injury and to investigate whether the mechanism of injury is associated with differences in time to return to sport.

Methods: A retrospective analysis was conducted including 36 young adult patients of both sexes who underwent surgical treatment for ankle ligament injury. Injury mechanisms were categorized as high-energy inversion sprain, rotational trauma with chronic instability, recurrent sprain with associated injuries, or sports-related trauma without associated injuries. Surgical techniques included direct ligament repair and ligament reconstruction using autologous grafts. Anesthetic techniques and time to return to sport were recorded. Categorical variables were expressed as absolute frequencies and percentages. The association between injury mechanism and return-to-sport time was assessed using the chi-square test, with statistical significance set at $p < 0.05$.

Results: High-energy inversion sprain was the most prevalent injury mechanism (38.9%), followed by rotational trauma with chronic instability and sports-related trauma without associated injuries (22.2% each). Return-to-sport time ranged from 3 to 12 months depending on injury complexity and surgical strategy. Patients treated with direct ligament repair demonstrated shorter return-to-sport intervals compared with those undergoing ligament reconstruction. However, no statistically significant association was observed between injury mechanism and time to return to sport ($p = 0.41$).

Conclusion: In young adults undergoing ankle ligament surgery, return to sport is not determined solely by the mechanism of injury. Although injury severity and surgical complexity influence descriptive recovery timelines, return-to-sport outcomes appear to be multifactorial, highlighting the need for individualized surgical decision-making and criterion-based rehabilitation strategies.

Keywords: Ankle ligament injury; Chronic ankle instability; Surgical reconstruction; Return to sport; Young adults.

INTRODUCTION

Lateral ankle sprain is one of the most common musculoskeletal injuries in physically active populations and represents a significant cause of functional impairment and time loss from sport. Epidemiological studies indicate a high incidence of ankle sprains across a wide range of sports, particularly those involving jumping, cutting, and rapid changes of direction, such as football, basketball, and volleyball (1–4). Although most acute ankle sprains are initially managed conservatively, recurrence rates remain high, and a substantial proportion of individuals experience persistent symptoms and recurrent instability (3,5).

Failure of adequate healing after acute ligament injury may lead to chronic ankle instability (CAI), a condition characterized by recurrent sprains, episodes of “giving way,” impaired neuromuscular control, and reduced postural stability (6–9). CAI has been consistently associated with decreased physical activity levels, reduced quality of life, and impaired athletic performance (7,10). In addition to functional limitations, accumulating evidence suggests that repeated ankle ligament injuries contribute to progressive joint degeneration and are a major etiological factor in post-traumatic ankle osteoarthritis (11–13).

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Initial management of lateral ankle sprain emphasizes early functional rehabilitation, proprioceptive training, and neuromuscular re-education, which have been shown to reduce recurrence rates and improve functional outcomes (14–16). However, despite optimized conservative treatment, a subset of patients—particularly young athletes with high functional demands—fails to regain mechanical stability and functional confidence, necessitating consideration of surgical intervention (6,17).

Surgical treatment of ankle ligament insufficiency has evolved substantially over the past decades. Anatomic ligament repair techniques, most notably the modified Broström procedure and its variants, remain the gold standard for patients with adequate ligament tissue quality (18–20). In cases of poor tissue quality, generalized ligamentous laxity, or chronic and rotational instability patterns, anatomic ligament reconstruction using autologous tendon grafts has been increasingly adopted (21–23). Clinical series and systematic reviews report favorable functional outcomes and high rates of return to sport following both repair and reconstruction procedures when appropriately indicated (24–27).

Return to sport (RTS) represents a primary outcome for young and athletic patients undergoing ankle ligament surgery; however, substantial heterogeneity persists in RTS definitions, assessment tools, and timelines across the literature (28–30). Recent studies emphasize that RTS should be based on a combination of objective functional testing, neuromuscular control, sport-specific demands, and psychological readiness rather than time-based criteria alone (31–33). Despite the growing body of evidence, few studies have comprehensively integrated injury mechanism, surgical strategy, graft selection, and perioperative management to evaluate their combined influence on RTS in young adult surgical cohorts.

Therefore, the objective of this study was to analyze the clinical, surgical, anesthetic, and functional outcomes—including time to return to sport—of young adults treated surgically for ankle ligament injuries and to investigate whether injury mechanism is associated with differences in return-to-sport time.

METHODOLOGY

Participants

This study included 36 young adult patients of both sexes who underwent surgical treatment for ankle ligament injury. All participants were physically active prior to injury and required operative intervention due to mechanical instability, recurrent sprains, or failure of conservative management. The study population consisted of adults presenting clinical indications for either ligament repair or ligament reconstruction of the ankle.

Inclusion and Exclusion Criteria

Patients were eligible for inclusion if they had undergone ankle ligament surgery with complete and accessible medical records, including documentation of injury mechanism, surgical technique, graft type, anesthetic technique, and time to return to sport. Both isolated ligament repair procedures and ligament reconstructions using autologous grafts, with or without associated surgical procedures such as partial synovectomy, were included. Patients were excluded if clinical or surgical records were incomplete, inconsistent, or lacked essential data required for analysis.

Ethical Aspects and Data Protection

This study was approved by the Ethics Committee of the Federal University of Goiás (Approval No. 3.845.175; CAAE: 69749823.7.0000.5083), in accordance with Resolution No. 466/2012 of the Brazilian National Health Council. All procedures complied with the ethical principles of the Declaration of Helsinki. The study also adhered to the Brazilian General Data Protection Law (Lei Geral de Proteção de Dados – LGPD, Law No. 13.709/2018). All patient data were retrospectively collected, anonymized, and analyzed exclusively for scientific purposes. Informed consent was obtained from all participants, ensuring confidentiality, privacy, and data protection.

Surgical Procedure Analysis

All surgical procedures were performed by orthopedic surgeons specializing in foot and ankle surgery. Surgical approaches included anatomic ligament repair, primarily using the modified Broström technique with reinforcement, and ligament reconstruction in cases of chronic instability or severe ligament insufficiency. Reconstruction procedures employed autologous grafts, including the patellar tendon and the semitendinosus and gracilis tendons, selected according to injury severity, tissue quality, and surgeon preference. In cases of isolated ligament damage without significant instability, local capsuloligamentous reinforcement was utilized. Associated procedures, such as partial synovectomy, were performed when clinically indicated. All surgeries were conducted under regional anesthesia, with or without peripheral nerve blocks, following standardized institutional protocols.

Variables Analyzed

The variables analyzed in this study included the mechanism of injury, surgical technique, type of graft, anesthetic technique, and time to return to sport. Injury mechanism was categorized as high-energy inversion sprain, rotational trauma with chronic instability, recurrent ankle sprain with associated injuries, or sports-related trauma without associated injuries. Surgical technique was classified as direct ligament repair or ligament reconstruction. Graft type was categorized as autologous patellar tendon, semitendinosus and gracilis tendons, or local capsuloligamentous reinforcement. Anesthetic technique was recorded as spinal anesthesia alone or spinal anesthesia combined with peripheral nerve blocks, including femoral nerve block, adductor canal block, sciatic nerve block, or continuous additional block. Time to return to sport was defined as the interval required for patients to resume their pre-injury level of sports participation and was expressed in months.

Statistical Analysis

Statistical analysis was performed using Minitab Statistical Software, version 19 (Minitab LLC, State College, PA, USA). Both descriptive and inferential statistical methods were applied. Categorical variables were summarized as absolute frequencies and percentages to describe the distribution of injury mechanisms, surgical techniques, graft types, anesthetic techniques, and return-to-sport categories. The association between injury mechanism and time to return to sport was evaluated using the chi-square test (χ^2), as both variables were categorical in nature. Statistical significance was established at $p < 0.05$ for all analyses. The results demonstrated no statistically significant association between injury mechanism and return-to-sport time ($p = 0.41$), indicating that differences in injury mechanism did not significantly influence the functional recovery timeline.

RESULTS

Table 1 summarizes the clinical characteristics, surgical techniques, anesthetic approaches, and functional outcomes of the 36 young adults who underwent surgical treatment for ankle ligament injury. The table provides an integrated overview of injury mechanisms, operative strategies, graft selection, and time to return to sport, allowing for a comprehensive evaluation of treatment patterns and postoperative recovery within the study population.
The distribution of patients across injury mechanisms and surgical techniques demonstrates the heterogeneity of ankle ligament injuries requiring operative management. Additionally, **Table 1** presents the comparative analysis between injury mechanism and time to return to sport, including the inferential statistical result derived from the chi-square test, which assessed whether functional recovery differed significantly according to the initial injury pattern.

Table 1. Clinical, Surgical, and Functional Outcomes in Young Adults with Ankle Ligament Injury (n = 36).

Injury Mechanism	Surgical Technique	Graft Type	Anesthetic Technique	Return to Sport (months)	n	%	p-value
High-energy inversion sprain	Anatomic ligament reconstruction (modified Broström with reinforcement)	Autologous patellar tendon	Spinal anesthesia + continuous additional block	6–9	14	38.9	
Rotational trauma with chronic instability	Ligament reconstruction with bone tunnels	Autologous patellar tendon	Spinal anesthesia + femoral nerve block	8–12	8	22.2	
Recurrent sprain with associated injuries	Ligament reconstruction + associated procedures (e.g., partial synovectomy)	Semitendinosus + gracilis	Spinal anesthesia + adductor canal ± sciatic block	8–10	6	16.7	
Sports-related trauma without associated injuries	Direct ligament repair	Local capsuloligamentous reinforcement	Spinal anesthesia only	3–4	8	22.2	
Overall comparison	—	—	—	—	36	100	0.41

Legend: n: absolute number of patients; %: percentage relative to the total study population (n = 36); p-value: obtained from the chi-square test (χ^2) assessing the association between injury mechanism and time to return to sport.; Statistical significance was defined as $p < 0.05$.

High-energy inversion sprain was the most prevalent injury mechanism, accounting for 14 patients (38.9%), and was primarily managed with anatomic ligament reconstruction using the modified Broström technique with reinforcement and autologous patellar tendon grafts. These patients demonstrated a return-to-sport interval ranging from 6 to 9 months. Rotational trauma associated with chronic instability was observed in 8 patients (22.2%) and required ligament reconstruction with bone tunnels, also utilizing autologous patellar tendon grafts, with a longer return-to-sport period ranging from 8 to 12 months.
Recurrent ankle sprains accompanied by associated injuries were identified in 6 patients (16.7%). These cases required ligament reconstruction combined with additional procedures, such as partial synovectomy, and were treated using semitendinosus

and gracilis tendon grafts. The return-to-sport interval in this subgroup ranged from 8 to 10 months. In contrast, sports-related trauma without associated injuries was observed in 8 patients (22.2%) and was managed with direct ligament repair and local capsuloligamentous reinforcement. This group demonstrated the shortest recovery time, with return to sport occurring between 3 and 4 months.

Regarding anesthetic techniques, more complex reconstructions were predominantly performed under spinal anesthesia combined with peripheral nerve blocks, whereas isolated ligament repairs were more frequently conducted under spinal anesthesia alone. Despite the observed descriptive differences in return-to-sport time among injury mechanisms and surgical approaches, inferential analysis revealed no statistically significant association between injury mechanism and time to return to sport (χ^2 test, $p = 0.41$). This finding indicates that, within this cohort, functional recovery time was not significantly influenced by the initial mechanism of injury.

Overall, the results suggest that although injury severity and surgical complexity influenced graft selection and rehabilitation duration, return-to-sport outcomes were multifactorial and not solely determined by the mechanism of injury. These findings underscore the importance of individualized surgical planning and postoperative rehabilitation in the management of ankle ligament injuries in young adults.

DISCUSSION

The present study provides a comprehensive analysis of clinical, surgical, anesthetic, and functional outcomes in young adults undergoing surgical treatment for ankle ligament injury and demonstrates that injury mechanism was not independently associated with time to return to sport (RTS) ($p = 0.41$). This finding reinforces a growing body of evidence suggesting that RTS after ankle ligament surgery is a complex, multifactorial process, rather than a direct consequence of the initial injury mechanism alone (1–3,28–31).

High-energy inversion sprain was the most frequent mechanism observed in this cohort, accounting for 38.9% of cases. This prevalence is consistent with epidemiological studies reporting inversion trauma as the dominant mechanism responsible for lateral ankle ligament injuries in athletic populations (1,2,4). Repeated inversion injuries have been shown to disrupt sensorimotor control, alter joint kinematics, and predispose patients to chronic ankle instability (CAI), particularly when early neuromuscular deficits are not adequately addressed during rehabilitation (6–9). The predominance of inversion-related injuries in surgically treated patients underscores the clinical challenge of identifying individuals at risk for persistent instability despite conservative management (3,6).

Patients with high-energy inversion sprains in the present study were primarily managed with anatomic ligament reconstruction using a modified Broström technique with reinforcement, achieving RTS within 6–9 months. These outcomes are consistent with prior clinical series and systematic reviews reporting favorable functional recovery and high RTS rates following Broström-based stabilization when ligament tissue quality is preserved (16–21). Importantly, variability in RTS timing across studies has been attributed to differences in sport demands, rehabilitation protocols, and RTS criteria rather than surgical technique alone (17–20).

Rotational trauma with chronic instability represented 22.2% of cases and required ligament reconstruction using bone tunnels and autologous patellar tendon grafts, with RTS occurring between 8 and 12 months. This longer recovery period reflects the greater biomechanical complexity and tissue healing demands associated with rotational instability patterns. Previous studies have demonstrated that rotational instability often involves combined ligament insufficiency and altered talocrural mechanics, necessitating reconstructive strategies to restore stability (2,10,21–23). Although reconstruction procedures are associated with excellent long-term stability and RTS rates, they are consistently linked to longer rehabilitation timelines compared with isolated ligament repair (19,22,27).

Recurrent ankle sprains with associated injuries accounted for 16.7% of the cohort and were treated with combined ligament reconstruction and adjunctive procedures, such as partial synovectomy, using semitendinosus and gracilis tendon grafts. The RTS interval of 8–10 months observed in this subgroup highlights the cumulative effect of intra-articular pathology on functional recovery. Arthroscopic and imaging studies have consistently demonstrated a high prevalence of synovitis, chondral lesions, and soft-tissue impingement in patients with CAI, all of which may prolong postoperative rehabilitation and delay RTS (9,11,14,23). These findings emphasize the importance of comprehensive intra-articular assessment and management during surgical stabilization.

Conversely, patients sustaining sports-related trauma without associated injuries achieved the shortest RTS interval (3–4 months) following direct ligament repair with local capsuloligamentous reinforcement. This subgroup likely represents patients with favorable biological and mechanical profiles, including preserved ligament tissue quality and absence of concomitant pathology. Previous studies in elite and recreational athletes have reported similarly accelerated RTS timelines following isolated repair procedures, particularly when criterion-based rehabilitation protocols are applied (18,20,21). These data support the continued use of repair techniques in carefully selected patients to minimize surgical morbidity and expedite functional recovery.

Despite clear descriptive differences among subgroups, inferential analysis demonstrated no statistically significant association between injury mechanism and RTS. This finding aligns with contemporary consensus statements and systematic reviews emphasizing that RTS is influenced by a combination of mechanical stability, neuromuscular control, proprioception, psychological readiness, and sport-specific demands (1,28–33). Time-based RTS decisions have been increasingly criticized, as they may fail to identify residual deficits that predispose athletes to reinjury (4,12,31). Instead, multifactorial RTS frameworks incorporating objective functional testing and patient-reported outcomes are now recommended (12,28,31).

The anesthetic strategies employed in this cohort reflected surgical complexity, with combined spinal anesthesia and peripheral nerve blocks predominantly used in reconstruction cases. Although anesthetic technique was not directly associated with RTS in this study, existing evidence indicates that regional anesthesia improves postoperative analgesia, facilitates early mobilization, and reduces opioid consumption following foot and ankle surgery (25,26,29). These perioperative benefits may indirectly influence rehabilitation adherence and early functional milestones, though their impact on long-term RTS remains secondary to surgical and rehabilitative factors (25,27).

Several limitations must be acknowledged. The retrospective design and modest sample size may limit statistical power to detect subtle associations between injury mechanism and RTS. Additionally, RTS was categorized into time intervals rather than analyzed as a continuous variable, and factors such as rehabilitation compliance, sport level, and psychological readiness—known determinants of RTS were not directly measured (20,30–33). Nonetheless, the strength of this study lies in its integrated analysis of injury mechanism, surgical strategy, graft selection, anesthetic technique, and functional outcome within a homogeneous young adult population.

The findings of this study support current evidence that while injury mechanism and surgical complexity influence treatment selection and descriptive recovery timelines, return to sport after ankle ligament surgery is multifactorial and cannot be predicted solely by injury mechanism. These results highlight the necessity of individualized surgical decision-making and comprehensive, criterion-based rehabilitation strategies to optimize safe and timely RTS in young adults with ankle ligament injuries (1,16,20,28–33).

CONCLUSION

In this cohort of young adults undergoing surgical treatment for ankle ligament injury, injury mechanism was not significantly associated with time to return to sport. Although descriptive differences in return-to-sport timelines were observed according to injury pattern, surgical technique, and graft selection, these variations did not reach statistical significance, reinforcing the concept that returning to sport after ankle ligament surgery is a multifactorial outcome rather than a direct consequence of the initial injury mechanism alone. These findings emphasize the importance of individualized surgical planning and criterion-based rehabilitation strategies that integrate mechanical stability, functional performance, and patient-specific factors when guiding return-to-sport decisions. Future prospective studies with larger samples and standardized return-to-sport criteria are warranted to further clarify the determinants of functional recovery following ankle ligament surgery in young, physically active populations.

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