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ACUTE DISTAL TIBIOFIBULAR SYNDESMOTIC INJURIES IN ANKLE FRACTURES

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A stable tibiofibular syndesmosis articulation maintains the tibiofibular alignment and is necessary for normal ankle function. An ideal syndesmotic reduction and stabilization strategy should replicate the orientation and stabilizing forces of the syndesmotic ligaments. The aim of this study is to evaluate the outcomes of operative treatment for tibiofibular syndesmosis rupture associated with malleolar fractures.

This study presents patients with tibiofibular syndesmosis disruption treated at the Orthopedic Clinic of the Clinical Center in Niš from January 2017 to January 2019. The subjects included individuals with malleolarfractures accompanied by tibiofibular syndesmosis injuries. Treatment involved malleolar fixation and transfixation of the tibiofibular syndesmosis. Radiographic, clinical, operative and statistical methods were used to evaluate the study objectives.

In the group of 46 subjects with tibiofibular syndesmosis rupture, there were 28 (61%) men and 18 (39%) women, with age ranging from 18 to 79 years (mean age = 43.6 ± 9.6 years). The predominant cause of injury was slipping and falling in 32 patients (70%), followed by falls from a height in 9 patients (19%), and traffic accidents in 5 patients (11%). According to the Lauge−Hansen classification, 27 (59%) patients sustained supination-external rotation type injuries. Based on the final functional treatment outcome assessed using the Olerud-Molander scoring system, the average ankle score was 87 points (range 55 to 100). Among the patients, 34 (74%) achieved excellent or good results: 24 (52%) had excellent outcomes (score from 90 to 100 points), and 10 (22%) had good outcomes (80 to 89 points). Satisfactory outcomes were observed in 7 (15%) patients, while poor outcomes were recorded in 5 patients (11%).

Our results indicate that stable and timely surgical reconstruction and fixation of the malleolus and tibiofibular syndesmosis enable functional restoration and recovery of the ankle joint with a low rate of complications.

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Key words: *syndesmosis injury, ankle fracture, joint repair, syndesmosis fixation*

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Introduction

The incidence of ankle fractures is 187 per 100,000 inhabitants (1:800) annually (1), accounting for 3.92% of all body fractures and ranking first among intra-articular fractures. It is estimated that 13−20% of all ankle fractures are accompanied by syndesmosis injuries. Such injuries can also occur in ankle sprains, affecting up to 18% of cases, particularly in sports activities (2, 3). Stable and precise articulation of the distal tibiofibular syndesmosis (DTFS) is essential for maintaining the tibiofibular alignment and enabling normal ankle movement. Anatomically, the syndesmosis is formed by the medial rough, convex surface of the distal fibula, which articulates with a triangular, depressed area on the distal tibia. The anterior edge of the tibial incisura is significantly more developed, and extends across the medial two-thirds of the fibula, thereby providing support and preventing anterior displacement of the fibula (4).

Syndesmosis is a fibrous joint in which two adjacent bones are connected by a strong membrane and ligaments. The syndesmosis ligament complex resists axial, translational, and rotational forces and thus provides syndesmotic stability. It consists of four components: the anterior inferior tibiofibular ligament (AITFL), posterior inferior tibiofibular ligament (PITFL), interosseous ligament (IOL), and transverse tibiofibular ligament (TTFL) (5, 6). The anatomical syndesmotic unit also includes the posterior

malleolus, to which the PITFL is attached. In cases of injury where the posterior malleolus is intact, the PITFL is torn by a type of avulsion from its attachment site on the malleolus. In posterior malleolus fractures, posterior syndesmosis ligaments may remain intact and attached to the fragment. In that case, malleolus fixation is required, because reduction of the ankle joint and greater syndesmotic stability can be achieved (6, 7). The lateral malleolus and syndesmosis are key structures for the anatomical reduction of dislocated ankle fractures. Restoring the integrity of the lateral malleolus is essential for reestablishing the overall stability of the ankle joint (8, 9).

Precise ankle joint congruence is essential for its movement, and malposition after trauma leads to significant adverse consequences that alter joint biomechanics and cause pathological compressive stress (10, 11). The aim of this paper is to evaluate the functional outcomes and possible anatomical changes in ankle joint cartilage after operative treatment of tibiofibular syndesmosis rupture associated with malleolar fractures.

Materials and Methods

Patients with disruption of distal tibiofibular syndesmosis treated at the Orthopedic Clinic of the Clinical Center in Niš during the period from January 2017 to January 2019 are presented. In a two-year period, there were 383 ankle injuries, and this study includes 46 patients (12% of the total number of injuries) with closed ankle fractures and associated syndesmotic rupture. Patients were regularly followed up at six and twelve months after surgery. Forclassificaton of ankle fractures, the Dennis−Weber classification (12) and the Lauge-Hansen classification (13) were used. Inclusion criteria for the study were acute syndesmotic injuries associated with ankle malleolar fractures (Dennis−Weber classification type B and C). Exclusion criteria were fibular fractures below the syndesmosis – (Dennis−Weber type A), open ankle fractures, and patients younger than 18 years.

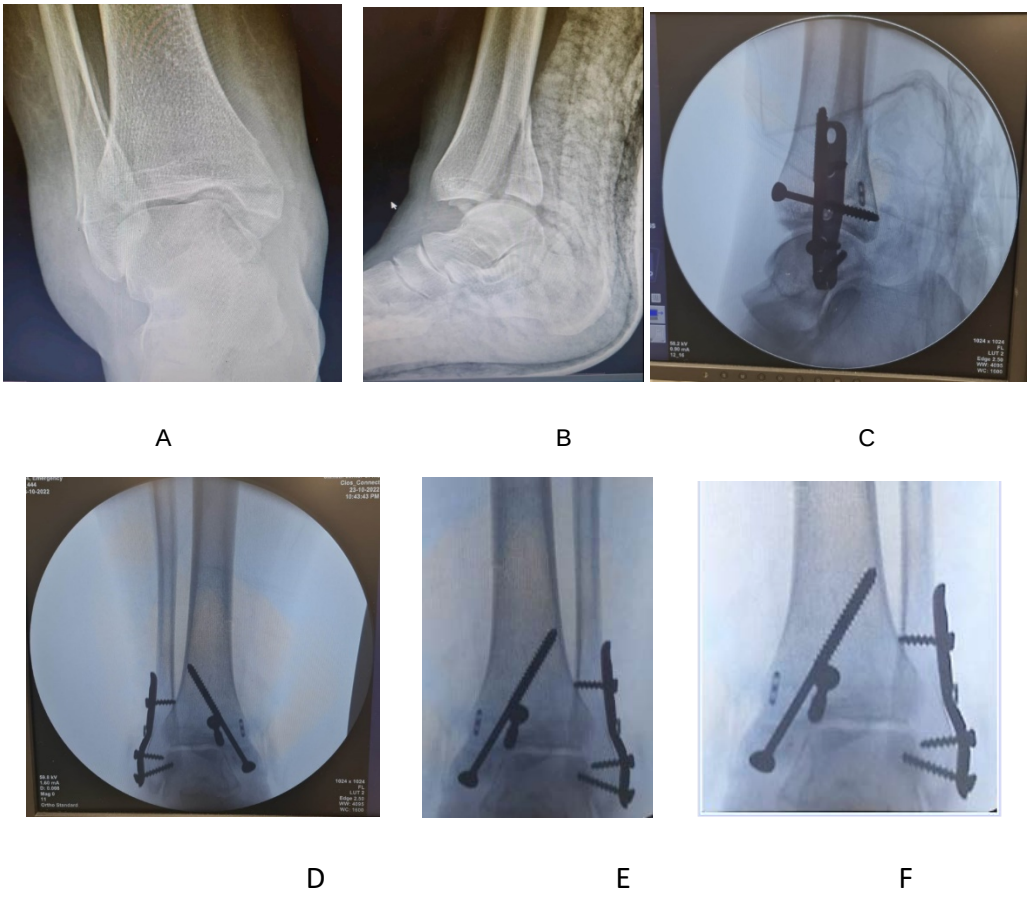
Radiographic method

For the purpose of accurate assessment of fractures and evaluation of treatment outcomes, radiography was performed in two standard projections. Standard anteroposterior (AP) radiographs were obtained with the foot in 20° internal rotation in men, and 15° in women. To obtain a true assessment of the ankle joint condition, the following parameters were measured: tibiofibular clear space (TCS) and tibiofibular overlap (TFO). These parameters reflect tibiofibular alignment, the degree of syndesmotic injury and fibular displacement, as well as the quality of postoperative reduction, and were used in our analysis. Radiographic evaluation was performed at admission, intraoperatively, postoperatively, and at six- and twelve-month follow-up. The Kellgren−Lawrence (KL) scale was used to assess the severity of post-traumatic osteoarthritis (PTOA) (14).

Operative method

Surgery was performed immediately after admission and preoperative preparation, on average after 30 ± 8.6 hours. If adequate fibula length, a reduced talocrural angle, and a centered talus were achieved, fibular fracture fixation was performed. A tibiofibular transfixation screw was placed either independently or through one of the distal plate holes, above the tibiofibular syndesmosis, i.e., 1.5 to 3.5 cm above the joint line.The transsyndesmotic screw was placed after previous radiological confirmation of syndesmotic reduction in order to avoid fibular malreduction within the incisura. In some cases, the transfixation screw involved four cortices, i.e., passed through the fibula and tibia, and in others through three cortices and the entire tibial metaphysis (Figure 1). The axis of the transfixation screw formed an angle of 30° with the line of the articular surface. It is not necessary to tighten it excessively, nor to maintain the foot at a 90° angle relative to the lower leg during screw insertion. In addition to rigid syndesmotic fixation, we also used dynamic fixation. For this type of syndesmotic fixation, we used a system consisting of two polyester strips and two titanium endobuttons (Figure 2). If internal fixation stability was adequate and wounds were satisfactory, passive and active mobilization of the ankle joint inoperated patients was initiated on the second operative day under the supervision of a physiotherapist. Patients stayed at the Clinic for 5 days (range 4−8) on average and were discharged home after being trained to walk with crutches. Partial weight bearing and support of the operated extremity with axillary crutches were allowed for up to 8−10 weeks, while full weight-bearing was permitted after 8−12 weeks.

Figure 1. Supination-external rotation (SER) type ankle fracture. A – Preoperative radiograph. B – Postoperative radiograph after surgical treatment with plate and screw fixation of the malleolus and rigid distal tibiofibular syndesmosis fixation. C – Anteroposterior radiograph six months postoperatively



Clinical method

After 12 months of follow-up, the functional outcomes of patients were evaluated. Assessment of subjective and objective symptoms was performed using the Olerud–Molander scoring system (15). Movements in the talocrural joint were measured with the patient in a prone position. The axis of the goniometer was placed on the lateralside of the heel, so that one arm followed the longitudinal axis of the foot, i.e., the fifth metatarsal bone, and the other arm followed the longitudinal axis of the lower leg along the fibular side. The final position of the foot in plantar flexion and dorsi flexion was measured. Osteosynthetic material was removed after an average of 7.5 months (range 5–14 months). Isolated removal of the syndesmotic screw and elastic fixation was not performed, except in two cases of syndesmotic screw loosening and skin infection.

Ethical Considerations

The research protocol of this study were reviewed and approved by the Ethics Committee and Professional Board of our Clinic.

Statistical Method

The statistical power was set at 0.80, with a significance level of 5% ($p < 0.05$) and a confidence interval of 95%. The normality of the data distribution was assessed using the Shapiro–Wilk test. The Mann–Whitney U-test was used for non-normally distributed numerical data. Values of the Olerud–Molander scoring system were analyzed using the χ^2 test, comparing observed and expected frequencies.

Results

The statistical results of the study are presented in tabular form (Table 1). In a group of 46 subjects with distal tibiofibular syndesmosis rupture, there were 28 (61%) men and 18 (39%) women, and patients' age ranged from 18 to 79 years ($\dot{x}$ = 43.6 ± 9.6 years). The most common cause of injury was slipping and falling reported in 32 patients (70%) followed by falls from height in 9 patients (19%) and traffic accidents in 5 patients (11%). According to the Lauge–Hansen classification, 27 (59%) patients sustained SER type injuries. The second most common was the pronation-abduction (PAB) type, observed in 14 (30%) patients, while 5 (11%) injuries were classified as the pronation-external rotation (PER) type.

Table 1. Schapiro–Wilk test of normality; Mean ($\bar{x}$) – sample mean; SD – standard deviation; SE – standard error; CI – 95% confidence interval; U-test (Wilcoxon rank-sum test). DFL – dorsi flexion (20°), PFL – plantar flexion (50°), TCS – tibiofibular clear space (< 6 mm), TFO – tibiofibular overlap (> 6 mm).

	DFL	**DFL**	**PFL**	**PFL**	**TCS**	**TCS**	**TFO**	**TFO**
	After 6 m.	After 12 m.	After 6 m.	After 12 m.	Before op.	After op.	Before op.	After op.
Shapiro–Wilk p > 0,05	0.000018	0.000011	0.016	0.34 x 10^{-7}	0.000091	1.85 x 10^{-7}	0.00085	0.00024
Average ($\bar{x}$)	14.15	15.73	36.04	39.34	8.76	4.96	2.74	8.65
SD	3.34	4.56	5.35	11.15	1.52	0.59	1.22	1.37
SE	0.493	0.672	0.789	1.644	0.224	0.087	0.18	0.20
Effect size	**small** (0.2)		**medium** (0.31)		**large** (0.88)		**large** (0.87)	
CI (95%)	14.45 ± 0.99	15.73 ± 1.3542	36.04 ± 1.5888	39.34 ± 3.3111	8.76 ± 0.4514	4.96 ± 0.175	2.74 ± 0.3623	8.65 ± 0.4068
Power	0.828		0.979		1.0		1.0	
U-test p < 0.05	**0.04969**, p (x ≤ Z) = 0.02484		**0.003412**, p (x ≤ Z) = 0.001706		**4.441e-16**, p (x ≤ Z) = 1		**0**, p (x ≤ Z) = 0	

All tested numerical data were not normally distributed (Shapiro–Wilk test: $p < 0.05$) (Table 1). A statistically significant difference was found in the values of dorsi flexion and plantar flexion of the foot between two measurements, at 6 months and 12 months ($p < 0.001$). Likewise, a statistically highly significant difference was observed TCS and TFO values before and after surgery ($p < 0.0001$). According to the Olerud–Molander scoring system, the average ankle score was $\bar{x}$ = 86.85 ± 3.73 points (95% CI: 83.13–90.59; SE: 1.85; range, 55–100 points). The obtained values were not normally distributed (Shapiro–Wilk test, $p = 0.0000314$). Thirty four (74%) patients had excellent or good results: 24 (52%) patients had excellent outcomes (90–100 points), and 10 (22%) patients had good outcomes (80–89 points). In these patients, the ankle joint was painless, physiological movements were preserved, and no visible deformities were observed. They returned to their usual work and sports activities. Satisfactory results were observed in 7 (15%) patients. These patients had occasional pain that increased during work, prolonged standing, and walking. Swelling of the ankle and foot was also present. At 12 months after surgery, they were unable to perform the same work as before the injury. Poor results were

recorded in 5 (11%) patients. These patients had constant pain and swelling of the ankle and foot. Movements in the ankle joint were reduced by more than 60%. They had difficulty ambulating with the use of aids and were unable to work or participate in sports 12 months after the injury. We compared the results of the Olerud–Molander test using the χ^2 test (Chi-square test for variance, χ^2 distribution, df = 45, two-tailed) in relation to the expected standard values of the overall population and found a statistically highly significant difference between the observed and expected values ($p < 1.709e-29$) with a small effect size (0.14). In patients with satisfactory (7; 15%) and poor results (5; 11%), postoperative complications were observed, including displacement of the fibular fracture and syndesmosis due to a short fibular plate and an inadequately long syndesmotic screw. In 2 (4.5%) patients, a transsyndesmotic screw fracture was identified. In 6 (13%) patients, bone loss with subsequent screw loosening was observed. In 9 (21.7%) patients, poor syndesmotic reduction persisted. In 10 (24%) patients, synostosis at the level of the tibiofibular syndesmosis was observed, and in one patient (2.2%), inadequate reduction and fixation of the medial malleolus were found. Prolonged wound healing and local infection were present in 3 (6.5%) patients. In 7 (16%) patients, post-traumatic osteoarthrosis of the ankle joint was observed 12 months after surgery: 5 patients had grade 1 changes according to the KL scale, and 2 patients had grade 2 ankle osteoarthritis.

Discussion

This study showed that rupture of the ligaments forming the syndesmosis results in the separation of the tibia and fibula, i.e., widening of the ankle mortise. Lateralization of the fibula occurs, with an increase in TCS and a decrease in TFO, thus creating the conditions for ankle joint instability. The study also showed that surgical intervention achieves adequate reconstruction of the tibiofibular syndesmosis and the ankle joint.

Khambete et al. (16) showed that normal ankle joint movement depends on a precise relationship determined by the syndesmosis. If the syndesmosis is disturbed, the tibiofibular joint space may widen and the talus may shift laterally, which alters the biomechanics of the tibiotalar joint, including contact surface ratio and pressure distribution. Burns et al. (17) showed that complete syndesmotic disruption combined with rupture of the deltoid ligament causes a 39% decrease in tibiotalar contact area and a 42% increase in pressure. There is no consensus on the optimal method for syndesmotic fixation. The two main methods are rigid fixation using a metallic syndesmotic screw, still considered "gold standard", and flexible dynamic stabilization using a suture-button system with endobuttons (2, 3, 18, 19). The transfixation screw is placed either independently or through the plate used for fibular fracture osteosynthesis. There are many controversies regarding syndesmotic screw fixation. Should the screw be placed through three or four cortices? It is considered that tricortical fixation is less rigid than quadricortical fixation and allows some degree of syndesmotic micromotion (20). Flexible dynamic stabilization is performed using a suture-button system, and consists of creating a nylon loop around the tibia and fibula at the level of the syndesmosis. The strip is placed in an anterior-posterior direction along the course of AITFL and PITFL fibers, i.e., following their anatomical axis. This is a relatively new method of fixation; it does not require ideal anatomical reduction of the syndesmosis and allows a certain degree of syndesmotic motion enabling potential self-reduction if the reduction is not anatomical (18, 19, 21).

The PITFL complex is an anatomical unit consisting of the ligament and the posterior malleolus and represents the core component of ankle joint stability, accounting for 42% of syndesmotic stability. The posterior malleolus should be considered key to anatomical syndesmosis reduction, and open reduction and direct fixation should be performed as the first step. Fixation of the posterior malleolus restores articular surface of the tibia, corrects fibular shortening, enables early weight-bearing and rehabilitation, and thus reduces the occurrence of post-traumatic osteoarthritis (6, 16, 22, 23).

Complications in tibiofibular syndesmosis treatment are possible and depend on the extent of soft tissue injury, fracture type, and the degree of cartilage damage to the talus and tibial plafond at the time of injury, as well as the quality of anatomical reduction. In our series, we observed complications that have also been reported by other authors. Hovis et al. (24) reported postoperative fibular fracture displacement in 9 (8.7%) and postoperative wound complications in 6 (5.9%) of 102 patients. Yablon et al. (8), in a study of 53 patients, reported infection in 2 (3.7%) cases and painful contact between talus and lateral maleolus, the so-called impingement, in 3 (5.6%) patients. They also reported talar instability predisposing to degenerative arthritis. Malreduction is a very common complicationand is defined by deviations in radiological parameters (TCS, TFO). It is manifested as malposition of the medial malleolus. In our series, malreduction was present in 10 (24%) patients. Ovaska et al. (25) reported malreduction in 9% of cases, while in 59% it referred specifically to syndesmosis malreduction. Sanders et al. (26) reported malreduction in 39% cases.

In their systematic review, Desouky et al. evaluated the outcomes of removing versus retaining syndesmotic screws in open and closed ankle fractures associated with unstable syndesmosis, based on functional, clinical, and radiological outcomes (27). Overall, the current literature provides no evidence to support routine removal of syndesmotic screws. Considering the potential complications and financial burden, syndesmotic screw removal should not be

performed unless there is a clear clinical indication (27).

A recent study by Qin Wang et al. conducted a meta-analysis synthesizing multiple sources of literature to investigate whether differences exist between elastic and rigid fixation in the treatment of acute tibiofibular syndesmosis injuries (28). The aim was to provide evidence-based guidelines for clinical management. The outcome measures included the American Orthopaedic Foot and Ankle Society (AOFAS) scores at 3, 6, and 12 months postoperatively; TBCS and TBOL at early postoperative assessment and at 12-month follow-up; intraoperative blood loss; operative time; time to full weight-bearing postoperatively; and postoperative complications. The meta-analysis was performed using Review Manager 5.4. A total of 35 studies were included, comprising 16 randomized controlled trials and 19 retrospective cohort studies. The study population included 2120 cases, with 1044 in the elastic fixation group and 1076 in the rigid fixation group. The elastic fixation group had higher AOFAS scores at 3, 6, and 12 months postoperatively compared with the rigid fixation group. The authors concluded that, compared with rigid fixation, elastic fixation in the treatment of acute tibiofibular syndesmosis injuries offers several advantages, including better postoperative ankle function recovery, more precise anatomical reduction of the syndesmosis, a lower incidence of postoperative complications, and shorter time to full weight-bearing. These findings provide useful guidelines for clinical practice (28).

In our study, we demonstrated favourable outcomes in the treatment of tibiofibular syndesmosis rupture and its impact on the consequences of ankle injury.

The limitations of this study include a small sample size for statistical analysis, which is why not all data were normally distributed; the influence of malleolar fractures on the development of PTOA was not considered; and no comparative measurements were performed with the contralateral healthy ankle. The study recommends further research focused on identifying factors contributing to ankle PTOA and exploring potential preventive measures. These may include the use of arthroscopy during surgical intervention to assess the condition of articular cartilage, removal of loose cartilage fragments, and early administration of chondroprotective agents.

Conclusion

This study demonstrated that surgical reconstruction of the ankle joint yields favourable outcomes. An almost anatomical position of the tibiofibular syndesmosis is achieved, resulting in stability and restoration of normal ankle biomechanics, which in turn reduces the incidence of complications.

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AKUTNE POVREDE DISTALNE TIBIOFIBULARNE SINDEZMOZE U PRELOMIMA SKOČNOG ZGLOBA

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Stabilna artikulacija tibiofibularne sindezmoze održava odnos između tibije i fibule i neophodna je za normalnu funkciju skočnog zgloba. Idealna strategija redukcije i stabilizacije sindezmoze treba da replicira orijentaciju i stabilizacione sile ligamenata. Cilj ove studije bio je da proceni rezultate operativnog lečenja rupture tibiofibularne sindezmoze udružene s prelomom maleolusa.

U radu su prikazani slučajevi pacijenata sa disrupcijom tibiofibularne sindezmoze koji su lečeni na Ortopedskoj klinici Kliničkog centra u Nišu od januara 2017. godine do januara 2019. godine. Pomenuti pacijenti su imali prelom maleolusa, koji je bio praćen povredama tibiofibularne sindezmoze. Pacijenti su lečeni fiksacijom maleolusa i transfiksacijom tibiofibularne sindezmoze. Za evaluaciju postavljenih ciljeva rada korišćene su radiografska, klinička, operativna i statistička metoda.

U grupi od 46 pacijenata sa rupturom tibiofibularne sindezmoze bilo je 28 (61 %) muškaraca i 18 (39%) žena, starih od 16 do 79 godina ($\bar{x}$ = 43,6 ± 9,6 godina). Dominanti uzroci povreda pacijenata bili su klizanje i pad (kod 32 pacijenta, odnosno kod 70%), pad sa visine (kod devet pacijenata, odnosno kod 19%) i saobraćajni udes (kod pet pacijenata, odnosno kod 11%). Prema Lauge–Hansen klasifikaciji, tip povreda kod 27 (59%) pacijenata bio je spoljašnje rotacioni. Na osnovu konačnog funkcionalnog rezultata lečenja po Olerud–Molander sistemu bodovanja, prosečna ocena skočnog zgloba za ove pacijente bila je 87 poena (opseg: od 55 do 100 poena). U grupi pacijenata sa odličnim i dobrim rezultatima bila su 34 (74%) pacijenta; od toga, 24 (52%) pacijenta imala su odličan rezultat (skor od 90 do 100 poena), a njih deset (22%) dobar rezultat (skor od 80 do 89 poena). Zadovoljavajući rezultati zabeleženi su kod sedam (15%) pacijenata, a loši rezultati kod pet (11%) pacijenata.

Dobijeni rezultati ukazuju na to da stabilna i pravovremena hirurška rekonstrukcija i fiksacija maleolusa i tibiofibularne sindezmoze dovodi do vraćanja funkcije i oporavka skočnog zgloba s minimalnim posledicama.

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***Ključne reči**: povreda sindezmoze, prelom skočnog zgloba, reparacija zgloba i sindezmoze*