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ACUTE DISTAL TIBIOFIBUAR SYNDESMOTIC INJURIES IN ANKLE FRACTURES

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Stable tibiofibular syndesmosis articulation maintains tibiofibular relation 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. Aim, this study evaluate the results of operative treatment of tibiofibular syndesmosis rupture associated with malleolar fractures.

Patients with tibiofibular syndesmosis disruption who were treated at the Orthopedic Clinic of the Clinical Center in Nis in period from January 2017 to January 2019 are presented. The paper presents subjects with a malleolus fracture followed by tibiofibular syndesmosis injuries. Malleolus fixation and transfixation of tibiofibular syndesmosis were performed. We used radiographic, clinical, operative and statistical methods to evaluate the set goals of work.

In the group of 46 subjects with tibiofibular syndesmosis rupture, there were 28 (61%) men and 18 (39%) women, age of patients ranged from 18 to 79 years (Ẋ= 43,6 ± 9,6 years). The cause of injuries is dominantly slipping and falling in 32 (70%) respondents, falling from a height in 9 (19%) and traffic accident in 5 (11%) respondents. According to the Lauge-Hansen classification, 27 (59%) respondents have supination-external rotation (SER) type injuries. Based on final functional treatmant outcome according to Olerud - Molander scoring system, the average ankle score for these patients was 87 points (range 55 to 100 points). In group of excellent and good results there were 34 (74%) patients, 24 (52%) patients had excellent results (score from 90 to 100 points), and 10 (22%) had good score (80 to 89 points). There were 7 (15%) respondents in group with satisfactory results. There were 5 (11%) respondents in group with poor results.

Our results indicate that stable and timely surgical reconstruction and fixation of the malleolus and tibiofibular syndesmosis leads to the return of function and recovery of the ankle joint with minimal consequences.

Keywords: syndesmosis injury, ankle fracture, joint and syndesmosis repair

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AKUTNE POVREDE DISTALNE TIBIOFIBULARNE SINDESMOZE KOD PRELOMA SKOČNOG ZGLOBA

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Stabilna artikulacija tibiofibularne sindesmoze održava tibiofibularni odnos i neophodna je za normalnu funkciju skočnog zgloba. Idealna strategija sindesmotske redukcije i stabilizacije treba da replicira orijentaciju i stabilizacione sile sindezmotičnih ligamenata. Cilj rada, ova studija evaluira rezultate operativnog lečenja rupture tibiofibularne sindesmoze udružene sa prelomima maleolusa.

Prikazani su pacijenti sa disrupcijom tibiofibularne sindesmoze koji su lečeni na Ortopedskoj klinici Kliničkog centra u Nišu u periodu od Januara 2017. do Januara 2019. godine. U radu su prikazani pacijenti sa prelomom maleolusa praćeni povredama tibiofibularne sindesmoze. Pacijenti su lečeni fiksacijom maleolusa i transfiksacijom tibiofibularne sindesmoze. Za evaluaciju postavljenih ciljeva rada, koristili smo radiografski, klinički, operativni i statistički metod.

U grupi od 46 pacijenata sa rupturom tibiofibularne sindesmoze bilo je 28 (61 %) muškaraca i 18 (39%) žena, a starost bolesnika se kretala od 16 do 79 godina, (Ẋ= 43,6 ± 9,6 godina). Kao uzrok povreda, dominira klizanje i pad, 32 (70%) pacijenta, pad sa visine 9 (19 %) i saobraćajni udes 5 (11 %). Prema Lauge - Hansen klasifikaciji, 27 (59%) pacijenata, ima spoljašnje rotacioni (SER) tip povreda. Na osnovu konačnog funkcionalnog rezultata lečenja po Olerud - Molander sistemu bodovanja, prosečna ocena skočnog zgloba za ove pacijente bila je 87 poena (opseg, 55 do 100 poena). U grupi odličnih i dobrih rezultata bilo je 34 (74%) pacijenta, 24 (52%) pacijenta imalo je odličan rezultat (skor od 90 do 100 poena), a 10 (22%) je imalo dobar rezultat (skor od 80 do 89 poena). U grupi zadovoljavajućih rezultata bilo je 7 (15%) pacijenata. U grupi sa lošim rezultatima bilo je 5 (11%) pacijenata.

Naši rezultati ukazuju da stabilna i pravovremena hirurška rekonstrukcija i fiksacija maleolusa i tibiofibularne sindesmoze, dovodi do vraćanja funkcije i oporavka skočnog zgloba sa minimalnim posledicama.

Ključne reči: povreda sindesmoze, prelom skočnog zgloba, reparacija zgloba i sindesmoze.

Introduction

The incidence of ankle fractures is 187 fractures per 100,000 (1: 800) inhabitants per year (1), ie 3.92% in relation to all body fractures and keep the first place in intra-articular fractures. It is estimated that 13-20% of all ankle fractures are accompanied by syndesmosis injury, the injury can also occur in ankle sprains, up to 18% of cases, and especially in sports (2, 3). Stable and precise articulation of distal tibiofibular syndesmosis (DTFS) maintains tibiofibular relation and is necessary for normal ankle movement. Anatomically, syndesmosis is formed by medial rough convex distal fibula surface, which is articulated with lateral incisor - depression, triangular in shape, of distal tibia. Anterior tibia incision edge is significantly more developed and crosses medial two-thirds of the fibula and thus serves as support for the fibula, so it doesn't move forward (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, and consists of 4 components: anterior inferior tibiofibular ligament (AITFL), posterior inferior tibiofibular ligament (PITFL), interosseous ligament (IOL) and transverse tibiofibular ligament (TTFL) (5, 6). The anatomical syndesmosis unit is also made of posterior malleolus to which PITFL is attached. In case of injury where posterior malleolus is intact, the PITFL is torn by type of delamination from junction site on malleolus. In posterior malleolus fractures, posterior syndesmosis ligaments may remain intact and attached to fragment. In that case, malleolus fixation is required, because reduction of the ankle joint and greater syndesmosis stability is achieved (6, 7). Lateral malleolus and syndesmosis are key for anatomical reduction of dislocated ankle fractures, and restoring lateral malleolus integrity restores ankle joint integrity (8, 9).

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

Material and methods

Patients with disruption of distal tibiofibular syndesmosis, treated at the Orthopedic Clinic of the Clinical Center in Nis in period from January 2017 to January 2019 are presented. In two years period, there were 383 ankle injuries, and the paper presents 46 patients, 12% of the total number of injuries, with closed ankle fractures and accompanying syndesmosis rupture. They were regularly monitored after six and twelve months after the surgery. For the division of ankle fractures, we used the Dennis-Weber classification (12) and the Lauge - Hansen classification (13).Criteria for the inclusion of subjects in the study are: acute syndesmosis injuries as part of ankle malleolus fractures - Denis Weber classification, type B, C. Patients with a fracture of the fibula below the syndesmosis - Dennis Weber classification, type A, open ankle fractures and younger than 18 years were excluded from the study.

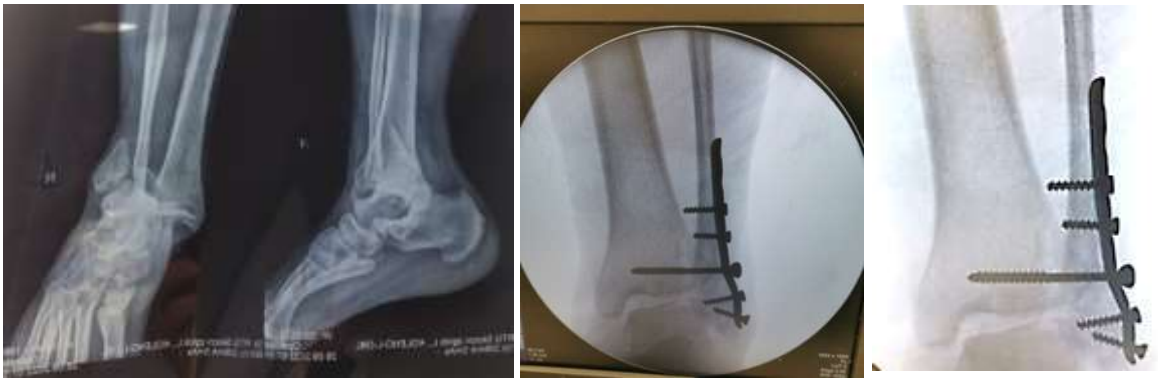
Radiographic method

For the purpose of true insight and objective assessment of fractures, as well as assessment of treatment results, radiography was performed in two basic projections. Standard AP radiographs are taken when the foot is 20 degrees in internal rotation in men, and 15 degrees in women. In order to have true insight into condition of ankle joint, we determined following parameters: tibiofibular clear space (TCS) and tibiofibular overlap (TFO). These are the parameters that show the tibiofibular relationship, the degree of syndesmosis rupture and dislocation of the fibula, as well as the quality of postoperative repositioning, which we also used in our analysis. We performed radiological control at the time of admission, during and after surgery, after the sixth and twelfth months. The Kellgren-Lawrence (KL) scale was used to assess the severity of post-traumatic osteoarthritis (PTOA), (14).

Operative method

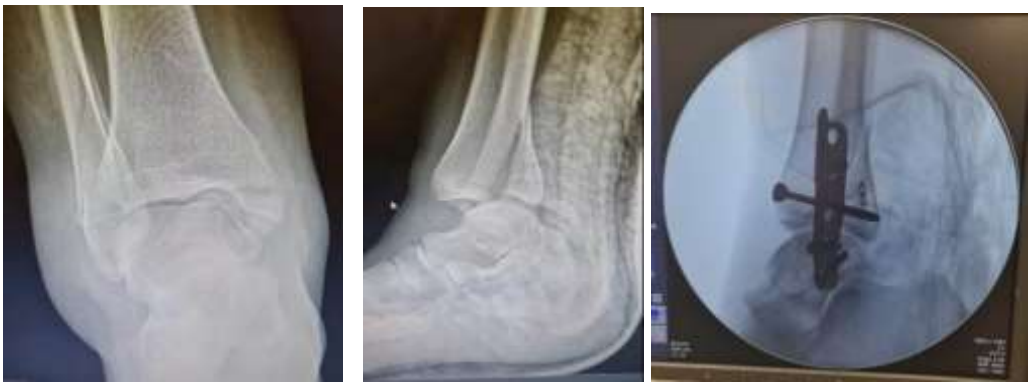
The surgery was performed immediately after admission and preparation for surgery, on average after 30 ± 8,6 hours. If good length of the fibula, reduced talocrural angle and centered talus is achieved, fibula fracture fixation is performed. Tibiofibular transfixation screw is placed independently or through one of the lower plate holes, above tibio fibular syndesmosis, ie. at 1.5 to 3.5 cm above the joint lin. We placed the transindesmal screw with previous radiological control of tibiofibular syndesmosis repopsition in order to avoid fibula malreduction in incisor. In some cases, the transfixation screw involved four cortices, i.e.

passed through the fibula and tibia, and in some through three cortices and the entire metaphysis of the tibia, (Figure 1). The axis of the transfixation screw made an angle of 30 degrees with the line of the articular fissure. It is not necessary to tighten it too much, nor to keep the foot at an angle of 90 degrees in relation to the lower leg during installation of the screw. Apart from this fixation of syndesmosis or the so-called rigid fixation, we also worked with the so-called dynamic fixation. For this type of syndesmosis fixation, we used a system consisting of two polyester strips and two titanium endo button, (Figure 2)**.** If internal fixation stability is good and wounds are satisfactory, passive and active mobilization of the ankle joint in the operated patients was started after the second operative day under the supervision of a therapist. Patients stayed at the Clinic for 5 days (range 4-8) in average, and were discharged home after previously being trained to walk with crutches. We allowed partial weight bearing and support of the operated extremity with the help of axillary crutches up to 8 - 10 weeks, while full weight bearing was allowed after 8 - 12 weeks.



A B C

Figure 1. Supination External Rotation (SER) type ankle fracture. A – Preoperative radiography. B – Radiography after surgical treatment with plate and screw fixation of the malleolus and DTFS rigid fixation system. C – AP radiography six months postoperatively



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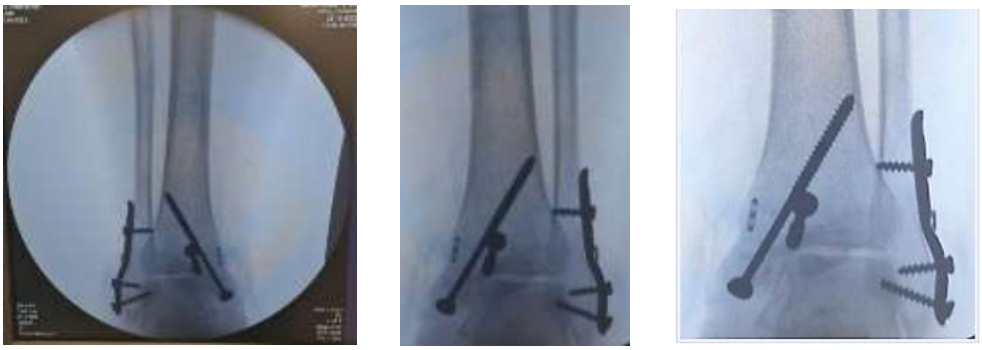

D E F

Figure 2. Radiography of a trimalleolar ankle fracture. A, B – Preoperative radiography. C, D – Radiography after surgical treatment with plate and screw fixation of the malleolus and DTFS dynamic fixation system – suture button. E, F – AP x - ray six and twelve months after surgery

Clinical method

After 12 months of follow-up, functional results of respondents were evaluated. Assessment of subjective and objective symptoms was performed using the Olerud-Molander scoring system (15). Movements in talocrural joint were measured in a lying position on the stomach, axis of the goniometer was placed on the outer side of heel, so that one arm follows longitudinal axis of foot, i.e. the fifth metatarsal bone, and other arm the longitudinal axis of lower leg on fibular side. We measured final position of foot in plantar and dorsiflexion. . The osteosynthetic material was removed after an average of 7.5 months (from 5 to 14 months). Isolated extraction of the syndesmotic screw screw and elastic fixation was not performed, except in two cases of syndesmotic screw screw loosening and skin infection.

Ethical consideration

Research propositions of this study were reviewed and approved by the Ethics Committee and Professional Board our Clinic.

Statistical method

We set the power of the tests we used at 0.80 with an alpha error level of 5% ($p < 0.05$) and a confidence interval of 95%. The normality distribution of the data was tested using the Shapiro-Wilk test. The Mann-Whitney U-test was used to test for not normally distributed numerical data. We tested values of the Olerud-Molander scoring system with the χ^2 test, evaluating its values in relation to the expected values of entire population.

Results

The statistical results of the research are shown in tabular form, (Table 1). In group of 46 subjects with lower tibiofibular syndesmosis rupture, there were 28 (61%) men and 18 (39%) women, and patients age ranged from 18 to 79 years ($\dot{X} = 43,6 \pm 9.6$ years). As the cause of injuries, slipping and falling dominate, 32 (70%) respondents, falling from height in 9 (19%) and traffic accident in 5 (11%) patients. According to Lauge-Hansen classification, 27 (59%) patients have supination-eversion (SER) type injuries. In second place is pronation-abduction (PAB) type of fracture, 14 (30%) patients, and 5 (11%) injuries are result of pronation-eversion (PER) type of ankle injury.

Table 1. Schap.W. - Schapiro Wilk test of normality distribution; Aver. ($\bar{x}$) - average of sample data; SD – standard deviation; SE - standard error; CI - confidence interval 95%; U-test: Mann-Whitney-U test (Wilcoxon rank test). DFL - dorsal flexion (20^0), PFL - plantar flexion (50^0),TCS - tibiofibular clear space (< 6 mm), TFO - tibiofibular overlap (> 6 mm).

	DFL	**DFL**	**PFL**	**PFL**	**TCS**	**TCS**	**TFO**	**TFO**
	After 6m	After12m	After 6 m.	After 12 m.	Bef.op	After op.	Bef.op	Aft.op
Schap.W. p>0,05	0.000018	0.000011	0.016	0.34 $x10^{-7}$	0.000091	1.85 $x10^{-7}$	0.00085	0.00024
Aver. ($\bar{x}$)	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. We found a statistically significant difference in the values of dorsal and plantar flexion of foot between two measurements, after 6 and after 12 months ($p<0.001$). Likewise, we found a statistically highly significant difference in the measurement of TCS and TFO values ($p<0.0001$) that were measured before and after surgery. According to the Olerud - Molander scoring system, the average ankle score was $\bar{x}$=86.85 ± 3.7299 points (CI 95%: 83.1301-90.5899; Margin of Error: 3.7299 ; Standard Error (S.E): 1.8519; range, 55-100 points) .The obtained test values were not normally distributed (Shapiro-Wilk test, p-value is 0.0000314). Thirty four (74%) patients had excellent and good results, 24 (52%) patients had an excellent result (score from 90 to 100 points), and 10 (22%) patients had a good result (80 - 89 points).

In these patients, the ankle joint was painless, physiological movements were preserved, and there were no visible deformities. They returned to their usual work and sports activities. There were satisfactory results in 7 (15%) patients. They had occasional pain, which increased during work, prolonged standing and walking. They had swelling in their ankle and foot. At 12 months after the operation, they could not do the same work they did before the injury. There were bad results in 5 (11%) patients. They had constant pain and swelling in the ankle and foot. Movements in the ankle joint were reduced by more than 60%. They had difficulty moving around with the help of aids and were unable to work or play sports 12 months after the injury. We compared the results of the Olerud Molander test with the χ^2 test (Chi-square test for variance, using χ^2 distribution (df=45) two-tailed) in relation to the expected standard values of the entire population and we obtained a statistically highly significant difference between our test values and the expected values ($p< 1.709e-29$) with a small effect size (effect size: small = 0.14). In patients with satisfactory 7 (15%) and poor results 5 (11%), postoperative complications developed: dislocation of the fibula fracture and syndesmosis due to a short plate on the fibula and a short screw fixing the tibiofibular syndesmosis. In 2 (4.5%) patients we found a transsyndesmal screw fracture. In 6 (13%) patients, we found bone loss and subsequent screw loosening. In 9 (21.7%) patients, poor syndesmosis reduction was constant. In 10 (24%) patients, synostosis was seen at the level of tibiofibular syndesmosis, and in one patient (2.2%), poor reposition and fixation of medial malleolus was found. Prolonged wound healing and local infection were present in 3 (6.5%) patients. In 7 (16%) patients, we found post-traumatic osteoarthrosis of the ankle joint 12 months after the operation, and in 5 patients grade 1 according to the KL scale and in 2 patients grade 2 ankle arthrosis.

Discussion

This study showed that the rupture of the ligaments that make up the syndesmosis results in the separation of tibia and fibula, that is. expansion of the joint fork. Lateralization of fibula occurs, enlargement of the TCS and reduction of the TFO, thus creating the conditions for instability of ankle joint. The study showed that surgical intervention achieves adequate reconstruction of tibiofibular syndesmosis and ankle joint.

Khambete et al. (16) showed that normal movement of ankle joint depends on precise relation determined by syndesmosis. If syndesmosis is disturbed, tibiofibular joint can expand and talus can move laterally, which changes mechanics of tibiotalar joint, ratio of contact surfaces and pressure. Burns et al. (17) showed that complete syndesmosis disorder combined

with rupture of deltoid ligament causes decrease in tibiotalar contact area by 39% and increase in pressure by 42%. There is no consensus on the optimal method for syndesmosis fixation. The two main methods are: rigid fixation method, which is performed using a metal syndesmotic screw, and is still considered "gold standard", and flexible dynamic stabilization, which is performed with a plastic strap with endo buttons (2, 3, 18, 19). The transfixation screw is placed independently or within the plate that performs fibula fracture osteosynthesis. There are many controversies surrounding syndesmotic screw. Should you place the screw through three or four cortexes? It is considered that tricortical fixation is not as rigid as tetracortical and provides certain syndesmosis micro-movements (20). Flexible dynamic stabilization is performed using plastic strip with endo buttons, and consists of making a nylon loop around tibia and fibula at the level of syndesmosis. The strip is placed anteriorly - posteriorly in direction of AITFL and PITFL fibers, ie. follows their anatomical axis. This is a new method of fixation, it does not require ideal anatomical reposition of syndesmosis, it allows certain movement in syndesmosis, so natural self-reduction occurs if it is not anatomical (18, 19, 21).

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

Complications in tibiofibular syndesmosis treatment are possible, and depend on the extent of soft tissue injuries, type of fracture and degree of damage to the cartilage of the talus and tibial ceiling at the time of injury, and the degree of anatomical reduction. In our series, we had complications that are reported by other authors. Hovis et al.(24) reports postoperative fibula fracture displacement in 9 (8.7%) and postoperative wound moistening in 6 (5.9%) of 102 patients. Yablon et al. (8) in study of 53 patients reported infection in 2 (3.7%), and painful contact of talus and lateral maleolus, the so-called impingement in 3 (5.6%) patients. He also states talar instability that predisposes to degenerative arthritis. Malreduction is a very common complication, and is defined on basis of deviations in values of radiological parameters (TCS, TFO). Malreduction is manifested as poor position of fibula in incisura fibularis, shortening of fibula or malreduction of malleolus medialis. In our series of patients,

malreduction was present in 10 (24%) patients. Ovaska et al. (25) reported malreduction in 9% cases, and in 59% it referred to syndesmosis malreduction. Sanders et al. (26) had malreduction in 39% cases.

In their systematic review, Desouky et al. examined comparing removal and non-removal of syndesmotic screws in open and closed ankle fractures associated with an unstable syndesmosis in terms of functional, clinical and radiological evidence (27). Overall, the current literature provides no evidence to support routine removal of syndesmotic screws. Keeping in mind the clear complications and financial burden, syndesmotic screw removal should not be performed unless there is a clear indication (27).

A recent paper by Qin Wang et al. used meta-analysis by synthesizing multiple sources of literature to investigate whether there are differences between elastic and rigid fixation in the treatment of acute tibiofibular syndesmosis injuries (28). The aim was to provide effective guidelines for clinical management. The outcome measures included AOFAS scores at 3, 6, and 12 months postoperatively; tibiofibular clear space (TBCS) and tibiofibular overlap distance (TBOL) at the early postoperative and 12-month follow-up; intraoperative blood loss; operative time; time to full weight-bearing postoperatively; and postoperative complications. Meta-analysis was performed using Review Manager 5.4. Results 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 cases in the elastic fixation group and 1076 cases in the rigid fixation group. The elastic fixation group had higher AOFAS scores at 3, 6, and 12 months postoperatively compared to the rigid fixation group. After this complex research, the conclusion was reached that compared to rigid fixation, elastic fixation in the treatment of acute tibiofibular syndesmosis injuries offers several advantages, including better postoperative ankle joint function recovery, more precise anatomical reduction of the syndesmosis postoperatively, a lower incidence of postoperative complications, and shorter time to full weight-bearing postoperatively. Certainly, these findings help us and provide strong guidelines for proper clinical work (28).

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

The disadvantages of this work are: a small sample for statistical data processing, which is why all data were not normally distributed; the impact of malleolus fracture on the explanation of the development of PTOA was not considered; no comparative measurements

were made with the opposite - healthy side. The recommendation of this study for further research is the search for PTOA factors of the ankle joint and possible prevention: the application of arthroscopy method during the surgical intervention for insight into the local status of the joint cartilage; removal of free cartilage parts; early administration of chondroprotectors.

Conclusion

This study showed that good results are obtained with surgical reconstruction of ankle joint. An approximately anatomical position of tibiofibular syndesmosis is achieved, it becomes stable and congruent to normal biomechanics of ankle joint, and this reduces the number of complications.

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