Review article
https://doi.org/10.18019/1028-4427-2024-30-1-142-152

Intramedullary osteosynthesis for ankle fractures and distal tibiofibular syndesmotic disruption

F.A. Gafurov[1], I.Yu. Khodzhanov[2], D.Sh. Mansurov[1]✉, Sh.N. Eranov[1]

[1] Samarkand State Medical University, Samarkand, Republic of Uzbekistan
[2] Republican Specialized Scientific-Practical Medical Center of Traumatology and Orthopedics, Tashkent, Republic of Uzbekistan

Corresponding author: Djalolidin Sh. Mansurov, jalolmedic511@gmail.com

Abstract

Introduction The optimal surgical approach for malleolar fractures and distal tibiofibular syndesmotic (DTFS) disruption remains controversial. There is no uniform treatment protocol for this type of injury.

The objective was to review modern surgical treatments of the pathology and determine the optimal option.

Material and methods Articles of French, English, Uzbek, Kazakh, German, Danish, Japanese and Chinese authors were retrospectively reviewed. An internet search of MedLine; PubMed; Scopus; Web of Science, CINAHL, the Cochrane Central Register of Controlled Trials databases was performed.

Results Comparative studies of dynamic fixation and static fixation of the DTFS showed advantages of the dynamic methods enabling precise, anatomical syndesmotic fixation and faster healing. Dynamic fixation methods would require no implant removal, while syndesmotic screw woul be taken off to reduce compression in the ankle joint and minimize a risk of malreduction facilitating mobility of the ankle joint. Dynamic methods are associated with greater stability and less complication rate. However, static methods have the advantages of being more accessible and less expensive, which can be an important factor choosing a treatment method. Static methods are a wide application and can be used in a wide range of clinical cases. Long-term results show no statistically significant differences between dynamic fixation and static fixation.

Discussion Literature review indicates the dynamic method with suture-button, a combined method and titanium cable isotonic annular fixation system as the preferred technique for surgical stabilization of distal syndesmosis associated with ankle fractures with a lower risk of postoperative complications and the possibility of short-term rehabilitation.

Conclusion The choice between dynamic and static methods of distal syndesmosis fixation depends on many factors, including the complexity of the injury, the availability and cost of implants and the experience of the surgeon.

Keywords: ankle fractures, tibiofibular syndesmosis disruption, dynamic fixation, static fixation, instability

For citation: Gafurov FA, Khodzhanov IYu, Mansurov DSh, Eranov ShN. Intramedullary osteosynthesis for ankle fractures and distal tibiofibular syndesmotic disruption. *Genij Ortopedii*. 2024;30(1):142-152. doi: 10.18019/1028-4427-2024-30-1-142-152

INTRODUCTION

Syndesmotic injuries occur during sporting activities, car accidents and other external effects. Once one has determined that syndesmotic injury will require surgical intervention, the surgeon needs to decide the most appropriate method of fixation. Syndesmotic fixation can be provided by bolts, wires, plates, wedges and other tools. Each method has advantages and disadvantages. Treatment would be dependent on the individual patient and injury characteristics. Safe and modern technologies are essential for improving the care of surgical patients. The distal tibia and fibula form the osseous part of the syndesmosis and are linked by the anterior tibiofibular ligament (ATIFL), the posterior tibiofibular ligament (PTIFL), transverse tibiofibular ligament (TTFL) and the interosseus ligament (Fig. 1) [1, 2].

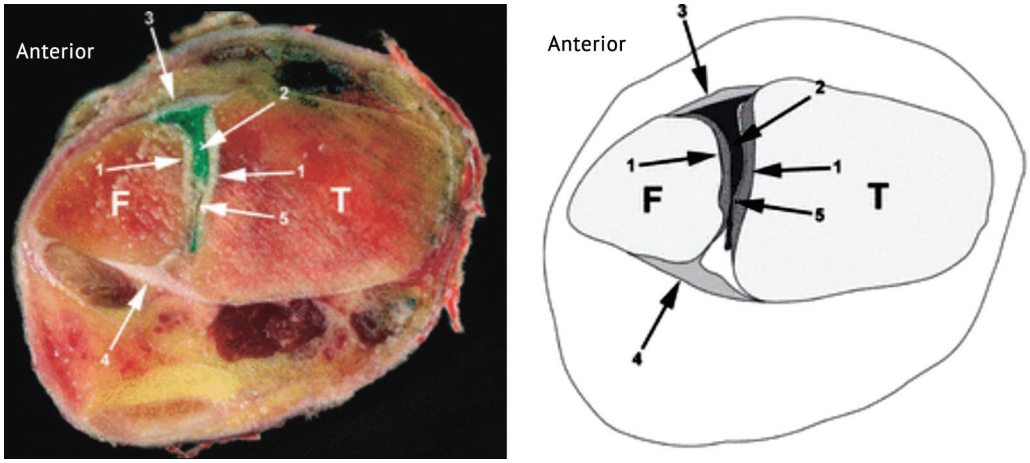

Fig. 1 Anatomical specimen and diagram of the distal tibiofibular syndesmosis: 1, cartilage; 2, syndesmotic recess; 3, anterior tibiofibular ligament; 4, posterior tibiofibular ligament; 5, interosseous ligament

Ankle fractures remain the third most common musculoskeletal injury and account for 5.5 to 7.4 % of all fractures seen in the trauma setting. Syndesmosis injuries account for 25 % of all ankle injuries and may result in significant functional impairment at a long term [3-8]. This applies to the Weber type C ankle fractures that often have an associated syndesmotic injury, the Weber type B ankle fractures that are usually caused by high energy injuries with syndesmosis involved in 37 % of cases [9-14]. Ankle fracture is caused by traumas such as falls, traffic accidents and sports-related injuries. The most common mechanism of injury is falls (66.5 %), with more fractures seen at winter periods [15]. Complications associated with surgical treatment of ankle fractures can have a significant impact on the patient's quality of life. Complications may be temporary and permanent resulting in disability and limited range of motion. If poorly managed, this type of injury can lead to long-term complications such as chronic pain, instability and osteoarthritis of the ankle [16-20].

Jody Litrenta et al. reported a slightly detrimental effect on outcomes of operatively treated ankle fractures in patients of multicenter randomized trial [21]. Surgical intervention is needed in many cases to address an injury and restore the function of the affected joint, which is currently the priority treatment for the pathology [7, 22-24]. This article will review current surgical options for ankle fracture associated with distal syndesmosis injury or rupture and their effectiveness in achieving optimal outcomes. The risks and benefits associated with each approach and the postoperative recovery and rehabilitation process will be discussed. There have been many studies comparing different surgical options. In 2019, Alberto Grassi, Kristian Samuelsson, Annunziato Amendola performed a meta-analysis of studies comparing dynamic fixation and static fixation of acute syndesmosis injuries and reported the superiority of dynamic fixation over static methods [22].

In 2017, Pei Zhang et al. reported advantages of a suture-button device over syndesmotic screw fixation in treatment of distal tibiofibular syndesmotic injuries [25]. Zhaofeng Jia and Jiwu Cheng investigated the clinical effects of a new technique, titanium cable isotonic annular fixation which showed advantages over current treatments of distal tibiofibular syndesmosis injury [26]. With the knowledge of the latest advances in the surgical treatment of ankle fractures involving syndesmosis, patients and healthcare providers can make informed decisions about the most appropriate strategy in a particular case, which is the purpose of this article.

The objective was to review modern surgical treatments of ankle fractures and distal tibiofibular syndesmotic disruption and determine the optimal option.

MATERIAL ANFD METHODS

Search strategy

An internet search of MedLine; PubMed; Scopus; Web of Science, CINAHL, the Cochrane Central Register of Controlled Trials databases was performed using the search terms “ankle fractures”, “rupture – injury to the distal syndesmosis”, “ankle fracture”, “syndesmosis injury”, “syndesmosis fixation”. All stages of selecting material for the article, including literature search, data extraction and quality assessment, were produced by the authors of the literature review, without additional funding or attraction of specialists who are supporters of a particular method of treatment. We also examined references to publications included in peer-reviewed articles, opinions of individual experts, and literature in the field of traumatology. The final search was performed on March 2, 2023.

Analysis and selection of information sources

Single cases of treatment, reports or abstracts were excluded. The search was carried out by each author independently, independently of other participants. The selection of suitable material was carried out through meetings of the authors, by discussing each source and voting for inclusion. In addition, the review included German and Danish studies presented in full text on the topic, including information on statistics and mechanisms of injury. Preference was given to large systematic reviews, randomized clinical trials with a high level of evidence (level 1-3 of the Oxford CEBM level of evidence)

Data collection and study quality assessment

All data were collected by reviewers according to uniform criteria. The study protocol (authors, titles, journals, years, type of studies, study protocol) was documented and the level of evidence considered. Statistical data were found in various regions and taken into account, including patient groups, number of patients, gender and age. Data on timing from injury to treatment, the time spent on surgery, Weber type of fracture, option of surgical fixation of the syndesmosis, long-term results and the number of postoperative complications which included surgical site infection, post-traumatic arthritis of the ankle joint, nonunion, limited range of motion and less common adverse events. The level of evidence was assessed based on the Oxford CEBM classification and the quality of the data. Almost all studies included functional monitoring using AOFAS, OMA, or ROM. The American Orthopedic Foot and Ankle Society (AOFAS) scale combines several patient-reported items concerning pain, function and alignment of the first ray. Each of the nine items is scored, accumulating to a total score ranging from 0 points (indicating severe pain and impairment) to 100 points (no symptoms or impairment).

The Olerud Molander ankle function score was used to evaluate the limb function after surgical treatment using a functional rating scale from 0 (totally impaired) to 100 (completely unimpaired).

The analysis included AOFAS and OMA scores measured at six months of surgery to 2 years. The range of motion of the ankle joint was highly individual for each person. Dorsiflexion, with the foot raising up, was approximately 20 degrees, and plantar flexion, with the foot coming down, was 30 degrees. This ROM was used as a reference for ankle kinematics. These measurements are important for assessment of ROM the range of motion in the affected joint, and a change is a marker of functional disorders of the ankle joint. A complication is defined as an adverse event associated with treatment that worsens treatment results or leads to the use of more complex protocols associated with a worse long-term prognosis and the use of more traumatic methods. An in-depth analysis of the literature resulted in the following data. The literature review included both articles examining various methods of surgical fixation of distal syndesmosis, and the comparative series. Next, the articles were carefully sorted into three groups, with the main sorting criterion being a type of surgical fixation of the distal syndesmosis. Open reduction and internal fixation (ORIF) using syndesmotic screws were reported in the articles on static fixation, ORIF using the suture-button was described in the studies on dynamic fixation, and ORIF in combination of syndesmotic screws and suture-buttons was reported in the articles on combined methods.

RESULTS

Thirty-seven contributions including meta-analyses, randomized controlled trials, cohort studies, which described surgical fixation of the distal tibiofibular joint and the comparison of long-term results, complications and mobility of the joint after a certain period of surgical treatment with the use of suture-button method (an example of dynamic fixation of the syndesmosis), the syndesmosis screw (an example of static fixation) and the combined method (using the syndesmosis screw and the suture-button method simultaneously). There are 3 main types of surgical fixation of the ankle joint. A syndesmotic screw is used for static fixation as a routine method of fixation of the distal syndesmosis. The suture button device using elastic materials offers dynamic fixation of the injured syndesmosis. A combined method has the advantages of both the static method and the dynamic techniques [25, 27-33]. The use of a syndesmotic screw is the gold standard for fixation of distal syndesmotic tears associated with ankle fractures.

All methods are used in traumatological practice and are safe but can be associated with complications, as with any surgical intervention, in the form of wound infections, implant failure, repeated surgical interventions, injury to the neurovascular bundles, chronic instability of the ankle joint, postoperative arthrosis and malreduction, which has a direct impact on the quality of life of patients, long-term results, and the extent of the ankle mobility [34-37]. The results of the studies showed differences in the incidence of complications between surgical treatment options. Static fixation was associated with the highest incidence of joint malreduction, implant failure and reoperation, and the highest incidence of non-anatomic syndesmotic fixation was characteristic of the dynamic group. The lowest rate of complications was observed in the group of combined methods due to syndesmosis fixation at the site of the anterior tibiofibular ligament and the posterior tibiofibular ligament reducing the risk of implant breakage and non-anatomical fusion, but increasing the risk of iatrogenic fracture [38-41].

Long-term results and kinematics of ankle joint movements

The findings showed that the three surgical techniques provided good functional results measured with the AOFAS score at 24 months or with physical examination of ankle ROM at a last follow-up, but there was a significant difference in duration of rehabilitation, where dynamic and combined methods of syndesmosis fixation showed advantages [28, 33, 34, 38]. In 2020, Neel K. Patel, Calvin Chan reported hybrid fixation as most appropriately restore tibiofibular kinematics for early

weightbearing, a lower risk of implant failure and a gap between the fibula and tibia, and limitations related to the age of the patients, bone density and severity of injury, which did not allow its use in routine practice, in older individuals, in particular [42]. N. Ramadanov et al. reported the difference in ankle ROM after static versus dynamic fixation describing a meta-analysis in greater detail. They found no statistically significant difference in dorsiflexion and plantar flexion during at 6 to 12 months of patient management [33].

Risk of re-operations associated with implant removal

Screw fixation of the distal syndesmosis sometimes requires reoperation in some cases to correct screw malposition, breakage, or nonunion. Reoperation may involve removing or repositioning the screw or applying a different type of fixation. The decision on a reoperation depends on the severity of the problem and the individual characteristics of the patient. Careful monitoring and follow-up is important to identify complications and ensure optimal outcome. Most non-specialized hospitals are experienced with routine removal of the syndesmotic screw, even in the absence of indications, which may be the reason for the low effectiveness of the technique in the period up to 6 months [43-47]. The studies showing comparison of button fixation and syndesmotic screws have demonstrated that static fixation methods often require removal of the metal construct due to the risk of implant breakage and decreased joint mobility, while dynamic methods do not require removal of the implant due to insignificant risk of device failure and its elasticity, low pressure at the site of the distal tibiofibular joint and the absence of significant limitation of the ankle mobility [25, 27-33].

Risk of joint malreduction

Ankle malreduction can occur in ankle fractures that involve syndesmosis and cause significant long-term complications such as chronic pain, instability, and early arthritis. Inadequate reduction may occur during fracture or during surgery. Proper reduction and alignment of the ankle joint is essential to maintain mobility. Imaging examination including radiography and computed tomography, can help diagnose and evaluate the extent of malreduction. Surgery may be required to address malreduction and realign the joint. Malreduction of the distal tibiofibular joint plays a role in the long-term results of surgical fixation; malreduction can increase the risk of repeated surgical interventions, development of instability of the distal tibiofibular joint reducing the quality of life of patients [48-50]. Although most studies have not shown a statistically significant superiority in the rate of malreduction of distal syndesmosis in the suture-button group, some systematic reviews and meta-analyses, a study performed by A. Grassi et al. in 2019, and a systematic review by K. Xu et al., conducted in 2021, showed that dynamic fixation is associated with a much lower risk of implant-related complications including malreduction [22, 29].

Risk of implant associated complications

Fixation of the distal syndesmosis with screws can be associated with implant-related complications including inadequate screw position and breakage causing persistent pain, instability and impaired ankle function. Implant-related complications are caused by malplaced screws or incompliance of the patient. Careful monitoring and surgical intervention are important to prevent complications and ensure optimal outcome. Numerous cohort studies, randomized clinical trials, and some meta-analyses have shown that dynamic ankle stabilization is associated with a lower risk of postoperative complications including implant failure, chronic instability, compression syndrome, bone irritation at the implant site, and infectious complications caused by slight compression at the fracture site improving blood supply which is very important for elderly patients [29, 33, 51].

Some meta-analyses, such as a systematic review conducted in 2019 by Alberto Grassi, Kristian Samuelsson showed no statistically significant advantage of dynamic methods with more complications seen in the group of static fixation [22].

Hybrid fixation of the ankle joint

There is a paucity of information on the topic. Hybrid fixation was reported in two articles of 2020 and 2021 [38, 42]. In 2020, Neel K. Patel and Calvin Chan reported lower risk of lateral translation in plantar flexion with postoperative results being comparable to the intact joint [42]. In 2021, hybrid fixation was reported to show a high accuracy of reduction, a low rate of diastasis, and favorable clinical outcomes in Weber type C fractures with syndesmosis injury [38]. Numan Mercan, Ahmet Yıldırım reported at least 15 % lower stress at the implant area with use of hybrid fixation as compared to other methods due to the the load distributed between the two independent fixation systems [52].

New Surgical Treatments for Ankle Instability

Over the years, surgical techniques for distal syndesmosis fixation have been improved, leading to improved results and fewer complications. A new technique employes taut cable bracing using a synthetic ligament to stabilize the ankle joint. This technique has shown promising results with good functional outcomes and lower complication rate compared with traditional screw fixation. The use of 3D printed implants can be practical for distal syndesmosis fixation. These implants are custom-made to fit each patient's unique anatomy, resulting in improved stability and a reduced risk of implant-related complications. Zhaofeng Jia, Jiwu Cheng, Haiyan Zhong developed a new technique using isotonic annular fixation. This technique has no disadvantages, unlike the suture-button and screw methods, and can restore the normal kinetics of the joint and resistance to load in the joint area. The technique is associated with a lower risk of implant failure, does not require routine removal, and allows the use of loading methods of rehabilitation early in the postoperative period [26]. In general, the study allowed us to conclude that the three surgical techniques are effective in the treatment of ankle fractures with injury to the syndesmosis, but each technique has advantages associated with the specific surgical method, type of implant, and disadvantages due to the characteristics of complications, long-term results and indications for use. Dynamic and hybrid methods of syndesmosis fixation are more practical in terms of rehabilitation and early weight-bearing on the limb. The static fixation is the method of choice for elderly patients with a lower risk of chronic joint instability, no need for rehabilitation and early loading on the joint, and no difference in the long-term period. Hybrid fixation is appropriate for younger patients with the possibility of early rehabilitation and early recovery of working capacity. Innovative methods can be considered for surgical fixation which may become new standards for the treatment of the pathology. Surgeons must carefully consider the patient's individual needs and extent of injury selecting a most appropriate surgical technique.

DISCUSSION

Comparison of different surgical treatments of ankle fractures with syndesmotic injuries is essential, as the selection of a most appropriate surgical technique can have a significant impact on patient outcomes. Comparisons in the series included open reduction and internal fixation (ORIF) using screws, ORIF with suture button fixation, and ORIF with a combination of screws and suture button fixation. New techniques that are not routinely used in everyday practice were also discussed. Surgical treatments of ankle fractures were presented in many studies. The button-suture method and the syndesmotic screw fixation were presented in a meta-analysis reported by Keteng Xu,

Jiale Zhang in 2020. Although the authors reported no statistically significant differences in radiological findings and clinical parameters with use of the methods at a long term however, the suture-button method was associated with a lower risk of bone damage at the implant site, implant failure and a decreased risk of malreduction. In addition to that, the duration of the rehabilitation period was shorter in the suture-button group [29]. Similar results were obtained in a meta-analysis performed by Nikolai Ramadanov, Simon Bueschges, Dobromir Dimitrov who also compared the button-suture method and the syndesmotic screw fixation of the ankle fracture with more detail to rehabilitation and risks of postoperative complications. The American Orthopedic Foot and Ankle Society score was identical in the groups at 6 months with long-term results being superior in the suture-button at 12 months but ultimately there was no significant difference in the outcomes at 24-month follow-up. Analysis of postoperative complications showed reduced risk of implant failure, bone damage at the site of implantation, joint malreduction and repeated operations with the use of the suture-button showing advantages of dynamic methods of syndesmosis fixation [33].

In 2019, Xiao Fan and Peng Zheng examined long-term outcomes and complications in a meta-analysis and reported no statistically significant difference in postoperative complications or long-term outcomes. The frequency of syndesmotic screw removal was the only significant difference [32]. In 2019, Alberto Grassi, Kristian Samuelsson reported significant evidence of a risk of complications reduced by 24 % compared to static fixation methods, the risk of implant-associated complications reduced by 25 %, higher AOFAS scores at a long term, greater ROM in the joint and effectiveness of early rehabilitation [22]. No significant difference in long-term results was reported in a systematic review performed by Pei Zhang, Yuan Liang in 2017 with advantages of the dynamic fixation observed in reducing the risk of postoperative complications, low cost, and low risk of malreduction of the syndesmosis, with no need to remove hardware [25]. In 2022, Jan Niklas Altmeppen, Christian Colcuc, et al. performed a prospective study and examined the results of surgical fixation of the distal syndesmosis over 10 years at a single clinic. The study showed no differences in the long-term results with various fixation methods and in the period of working rehabilitation did not differ and measured 10 weeks, regardless of the type of surgical treatment [27].

There are many studies reporting the need of the distal syndesmosis fixation and routine placement of metal constructs. In 2015, Jody Litrenta, David Saper and Paul Tornetta examined the effect of distal syndesmosis injury on long-term outcomes. They found that although the outcomes of patients without damage to the syndesmosis were better than those in the group with injury to the distal tibiofibular joint, the difference was slightly higher than the statistical threshold [21]. In 2021, Nuno Corte-Real, João Caetano reported the distal syndesmosis playing the major role in the ankle stabilization [16], the authors also confirmed The role of the distal syndesmosis fixation was reported in a retrospective cohort study performed in 2022, reducing the risk of chronic instability and rehabilitation period [53]. May Fong Mak, Richard Stern reported the use of an anatomical approach in restoration of the distal tibiofibular joint and showed promising results as compared with intraosseous fixation methods [28]. In 2020, FA Gafurov reported the need of surgical fixation of the distal syndesmosis is necessary [54].

The effectiveness of early postoperative weight-bearing on the involved joint is debatable. Ramy Khojaly, Fiachra E Rowan performed meta-analysis in 2022 and reported good functional outcome of early weight-bearing at 6 weeks with insignificant results observed at 6 and at 12 months of surgery [55]. Kiera A Kingston, Ye Lin produced a retrospective study in 2023 and reported the quality of life of patients with chronic ankle instability improved by more than 70 % [56]. VA Selivanov, MO Zhumagulov used an arthroscopic method for restoring syndesmosis with the

posterior inferior tibiofibular ligament being intact; the method provided the possibility of early weight-bearing on the joint and a lower risk of complications [57]. Although a study conducted by Sai-Kit Lim, Yui-Chung Ho in 2021 showed worse long-term results of ligament restoration as compared to routine fixation of the distal articulation using various methods of surgical correction for its instability [58].

Methods of the distal syndesmosis fixation have been developing with every decade, and isotonic annular fixation devised by Zhaofeng Jia, Jiwu Cheng, Haiyan Zhong is one of the methods. The results with the method are similar to those with hybrid fixation due to easy performance being associated with a lower risk of postoperative complications as compared to other surgical treatments of ankle instability [26]. Using only one surgical strategy as a priority in the treatment of this pathology would be a wrong decision. The use of each technique can be significantly limited considering the mechanism of injury, the time period with the greater risk of occurrence of this pathology, as well as associated factors, such as the Weber type of fracture, body mass index, age, the presence of osteoporosis.

The choice of surgical technique should rely on several factors, including the severity of the injury, the patient's age and the surgeon's experience and preference. For example, younger patients with more severe injuries may benefit from ORIF combined with screws and button suture, and older patients with less severe injuries may benefit from ORIF using screws alone. A combined technique using a syndesmotic screw and suture-button can be practical for athletes who can initiate early rehabilitation. A relatively small sample size of the data and its relatively low quality are one of the limitations of the study, which may confine generalizability of the findings. Studies with levels of evidence 1-3, with larger cohort of patients and longer follow-up are needed to confirm these results.

In conclusion, the choice of surgical technique for ankle fractures with syndesmotic injury should be individualized based on the patient's needs and the extent of injury. The three surgical techniques compared in the study are effective in achieving good functional results, but each technique has advantages and disadvantages in terms of complication rates. Surgeons must carefully consider these factors when selecting the most appropriate surgical technique.

CONCLUSION

Surgical treatment of distal syndesmotic tears associated with ankle fractures is a complex and multi-staged process that requires selection of the most optimal fixation. Various methods of static fixation using screws and plates and new approaches of dynamic fixation are employed for the surgery. Dynamic fixation uses flexible devices that allow a degree of movement and flexibility during the healing process, as opposed to static fixation, which immobilizes the joint with rigid devices. Dynamic fixation is beneficial in maintaining normal range of motion during the healing process, which can improve functional outcomes and reduce the risk of postoperative stiffness and pain. It may also reduce the risk of postoperative complications including screw breakage or loosening, joint space widening or joint instability during healing. However, dynamic fixation cannot be applied for all patients. The choice of fixation method depends on the severity and location of the fracture, individual characteristics and preferences of the patient. Careful evaluation of each case and the choice of the most optimal fixation are essential. Overall, dynamic fixation and hybrid fixation represent a promising approach to the treatment of distal syndesmotic tears that may improve patient outcomes and reduce complications. More research is needed to evaluate the effectiveness and safety of these methods.

Conflict of interest *The authors declare no conflict of interest.*

Funding *The study was conducted without sponsorship.*

Ethical review *Not applicable.*

Informed consent *Not applicable.*

REFERENCES

1. Hermans JJ, Beumer A, de Jong TA, Kleinrensink GJ. Anatomy of the distal tibiofibular syndesmosis in adults: a pictorial essay with a multimodality approach. *J Anat*. 2010;217(6):633-645. doi: 10.1111/j.1469-7580.2010.01302.x
2. Yammine K, Jalloul M, Assi C. Distal tibiofibular syndesmosis: A meta-analysis of cadaveric studies. *Morphologie*. 2022;106(355):241-251. doi: 10.1016/j.morpho.2021.10.004
3. Bilge O, Dündar ZD, Atılgan N, et al. The epidemiology of adult fractures according to the AO/OTA fracture classification. *Ulus Travma Acil Cerrahi Derg*. 2022;28(2):209-216. doi: 10.14744/tjtes.2020.26374
4. van Zuuren WJ, Schepers T, Beumer A, Sierevelt I, van Noort A, van den Bekerom MPJ. Acute syndesmotic instability in ankle fractures: A review. *Foot Ankle Surg*. 2017;23(3):135-141. doi: 10.1016/j.fas.2016.04.001
5. Zhang YW, Rui YF. A systematic review of the "Logsplitter" injury: how much do we know? *Injury*. 2021;52(3):358-365. doi: 10.1016/j.injury.2020.11.043
6. Ibrahim IO, Velasco BT, Ye MY, et al. Syndesmotic screw breakage may be more problematic than previously reported: increased rates of hardware removal secondary to pain with Intraosseous screw breakage. *Foot Ankle Spec*. 2022;15(1):27-35. doi: 10.1177/1938640020932049
7. Vander Maten JW, McCracken M, Liu J, Ebraheim NA. Syndesmosis screw breakage: An analysis of multiple breakage locations. *J Orthop*. 2022 22;29:38-43. doi: 10.1016/j.jor.2022.01.004
8. Li JK, Yu Y, Wu YH, et al. Does the level of syndesmotic screw insertion affect clinical outcome after ankle fractures with syndesmotic instability? *Orthop Surg*. 2023;15(1):247-255. doi: 10.1111/os.13569
9. Cornu O, Manon J, Tribak K, Putineanu D. Traumatic injuries of the distal tibiofibular syndesmosis. *Orthop Traumatol Surg Res*. 2021;107(1S):102778. doi: 10.1016/j.otsr.2020.102778
10. Bible JE, Sivasubramaniam PG, Jahangir AA, et al. High-energy transsyndesmotic ankle fracture dislocation - the "Logsplitter" injury. *J Orthop Trauma*. 2014;28(4):200-204. doi: 10.1097/01.bot.0000435605.83497.53
11. Gruenewald LD, Leitner DH, Koch V, et al. Diagnostic value of DECT-based collagen mapping for assessing the distal tibiofibular syndesmosis in patients with acute trauma. *Diagnostics* (Basel). 2023;13(3):533. doi: 10.3390/diagnostics13030533
12. Alvarez-López A, Valdebenito-Aceitón V, Soto-Carrasco SR. Tibioperoneal syndesmosis: diagnosis, fixation methods and arthroscopy. *Revista Información Científica*. 2023;102:4087. (In Span.) doi: 10.5281/zenodo.7768163
13. Rammelt S, Obruba P. An update on the evaluation and treatment of syndesmotic injuries. *Eur J Trauma Emerg Surg*. 2015;41(6):601-614. doi: 10.1007/s00068-014-0466-8
14. Lou Z, Wang Z, Liu C, Tang X. Outcomes of tibial pilon fracture fixation based on four-column theory. *Injury*. 2023;54 Suppl 2:S36-S42. doi: 10.1016/j.injury.2022.08.017
15. Rydberg EM, Wennergren D, Stigevall C, et al. Epidemiology of more than 50,000 ankle fractures in the Swedish Fracture Register during a period of 10 years. *J Orthop Surg Res*. 2023;18(1):79. doi: 10.1186/s13018-023-03558-2
16. Corte-Real N, Caetano J. Ankle and syndesmosis instability: consensus and controversies. *EFORT Open Rev*. 2021;6(6):420-431. doi: 10.1302/2058-5241.6.210017
17. Cogan C, Liu T, Toogood P. An assessment of normal tibiofibular anatomy on lateral fluoroscopy. *Foot Ankle Int*. 2020;41(7):866-869. doi: 10.1177/1071100720917639
18. Carrozzo M, Vicenti G, Pesce V, et al. Beyond the pillars of the ankle: A prospective randomized CT analysis of syndesmosis' injuries in Weber B and C type fractures. *Injury*. 2018;49 Suppl 3:S54-S60. doi: 10.1016/j.injury.2018.10.005
19. Kaiser PB, Bejarano-Pineda L, Kwon JY, et al. The syndesmosis, Part II: Surgical treatment strategies. *Orthop Clin North Am*. 2021;52(4):417-432. doi: 10.1016/j.ocl.2021.05.011
20. Dean DM, Ho BS, Lin A, et al. Predictors of patient-reported function and pain outcomes in operative ankle fractures. *Foot Ankle Int*. 2017;38(5):496-501. doi: 10.1177/1071100716688176
21. Litrenta J, Saper D, Tornetta P 3rd, et al. Does syndesmotic injury have a negative effect on functional outcome? A multicenter prospective evaluation. *J Orthop Trauma*. 2015;29(9):410-413. doi: 10.1097/BOT.0000000000000295
22. Grassi A, Samuelsson K, D'Hooghe P, et al. Dynamic stabilization of syndesmosis injuries reduces complications and reoperations as compared with screw fixation: a meta-analysis of randomized controlled trials. *Am J Sports Med*. 2020;48(4):1000-1013. doi: 10.1177/0363546519849909
23. Regauer M, Mackay G, Nelson O, Böcker W, Ehrnthaller C. Evidence-based surgical treatment algorithm for unstable syndesmotic injuries. *J Clin Med*. 2022;11(2):331. doi: 10.3390/jcm11020331
24. Elabd A, Abdullah S, Kandel W, Hegazy M. Syndesmotic stabilization: syndesmotic screw versus flexible fixation: a systematic review. *J Foot Ankle Surg*. 2021;60(5):998-1007. doi: 10.1053/j.jfas.2020.09.021

25. Zhang P, Liang Y, He J, et al. A systematic review of suture-button versus syndesmotic screw in the treatment of distal tibiofibular syndesmosis injury. *BMC Musculoskelet Disord*. 2017;18(1):286. doi: 10.1186/s12891-017-1645-7
26. Jia Z, Cheng J, Zhong H, et al. Titanium cable isotonic annular fixation system for the treatment of distal tibiofibular syndesmosis injury. *Am J Transl Res*. 2019;11(8):4967-4975.
27. Altmeppen JN, Colcuc C, Balser C, et al. A 10-year follow-up of ankle syndesmotic injuries: prospective comparison of knotless suture-button fixation and syndesmotic screw fixation. *J Clin Med*. 2022;11(9):2524. doi: 10.3390/jcm11092524
28. Mak MF, Stern R, Assal M. Repair of syndesmosis injury in ankle fractures: Current state of the art. *EFORT Open Rev*. 2018;3(1):24-29. doi: 10.1302/2058-5241.3.170017
29. Xu K, Zhang J, Zhang P, et al. Comparison of suture-button versus syndesmotic screw in the treatment of distal tibiofibular syndesmosis injury: a meta-analysis. *J Foot Ankle Surg*. 2021;60(3):555-566. doi: 10.1053/j.jfas.2020.08.005
30. Schulte SS, Oplinger SL, Graver HR, et al. Suture button versus screw fixation for distal tibiofibular injury and expected value decision analysis. *Cureus*. 2021;13(11):e19890. doi: 10.7759/cureus.19890
31. Lurie BM, Paez CJ, Howitt SR, Pennock AT. Suture-button versus screw fixation in adolescent syndesmotic injuries: functional outcomes and maintenance of reduction. *J Pediatr Orthop*. 2021;41(6):e427-e432. doi: 10.1097/BPO.0000000000001803
32. Fan X, Zheng P, Zhang YY, Hou ZT. Dynamic fixation versus static fixation in treatment effectiveness and safety for distal tibiofibular syndesmosis injuries: a systematic review and meta-analysis. *Orthop Surg*. 2019;11(6):923-931. doi: 10.1111/os.12523
33. Ramadanov N, Bueschges S, Dimitrov D. Comparison of outcomes between suture button technique and screw fixation technique in patients with acute syndesmotic diastasis: a meta-analysis of randomized controlled trials. *Foot Ankle Orthop*. 2021;6(4):24730114211061405. doi: 10.1177/24730114211061405
34. Pogliacomi F, De Filippo M, Casalini D, et al. Acute syndesmotic injuries in ankle fractures: From diagnosis to treatment and current concepts. *World J Orthop*. 2021;12(5):270-291. doi: 10.5312/wjo.v12.i5.270
35. Kodirkulov ZhSh, Zhamatov AK, Gafurov FA, Yarmatov EI. Current concept of treatment of patients with injuries of the tibiofibular syndesmosis. *Scientific Progress*. 2021;2(7):944-951. (In Russ.)
36. Hosin S, Vermesan D, Prejbeanu R, et al. Avoiding the removal of syndesmotic screws after distal tibiofibular diastasis repair: a benefit or a drawback? *J Clin Med*. 2022;11(21):6412. doi: 10.3390/jcm11216412
37. Saad BN, Rampertaap Y, Menken LG, et al. Direct versus indirect posterior malleolar fixation in the treatment of trimalleolar ankle fractures: Is there a difference in outcomes? *OTA Int*. 2022;5(4):e219. doi: 10.1097/OI9.0000000000000219
38. Kim GB, Park CH. Hybrid fixation for Danis-Weber type C fractures with syndesmosis injury. *Foot Ankle Int*. 2021;42(2):137-144. doi: 10.1177/1071100720964799
39. Bartoníček J, Rammelt S, Tuček M. Maisonneuve fractures of the ankle: a critical analysis review. *JBJS Rev*. 2022;10(2). doi: 10.2106/JBJS.RVW.21.00160
40. Harris MC, Lause G, Unangst A, et al. Prospective results of the modified glide path technique for improved syndesmotic reduction during ankle fracture fixation. *Foot Ankle Int*. 2022;43(7):923-927. doi: 10.1177/10711007221081868
41. Çağlar C, Akçaalan S, Akkaya M. Anatomically fixed posterior malleolar fractures in syndesmosis injuries without transsyndesmotic screw fixation. *Foot Ankle Int*. 2022;43(4):486-494. doi: 10.1177/10711007211060067
42. Patel NK, Chan C, Murphy CI, et al. Hybrid fixation restores tibiofibular kinematics for early weightbearing after syndesmotic injury. *Orthop J Sports Med*. 2020;8(9):2325967120946744. doi: 10.1177/2325967120946744
43. Sanders FRK, Birnie MF, Dingemans SA, et al. Functional outcome of routine versus on-demand removal of the syndesmotic screw: a multicentre randomized controlled trial. *Bone Joint J*. 2021;103-B(11):1709-1716. doi: 10.1302/0301-620X.103B11.BJJ-2021-0348.R2
44. Gennis E, Koenig S, Rodericks D, et al. The fate of the fixed syndesmosis over time. *Foot Ankle Int*. 2015;36(10):1202-1208. doi: 10.1177/1071100715588186
45. Hennings R, Fuchs C, Spiegl UJ, et al. "Flexible nature of fixation" in syndesmotic stabilization of the inferior tibiofibular joint affects the radiological reduction outcome. *Int Orthop*. 2022;46(11):2649-2657. doi: 10.1007/s00264-022-05550-7
46. Dingemans SA, Rammelt S, White TO, et al. Should syndesmotic screws be removed after surgical fixation of unstable ankle fractures? a systematic review. *Bone Joint J*. 2016;98-B(11):1497-1504. doi: 10.1302/0301-620X.98B11.BJJ-2016-0202.R1
47. Pfeifer CG, Grechenig S, Frankewycz B, et al. Analysis of 213 currently used rehabilitation protocols in foot and ankle fractures. *Injury*. 2015;46 Suppl 4:S51-S57. doi: 10.1016/S0020-1383(15)30018-8
48. Futamura K, Baba T, Mogami A, et al. Malreduction of syndesmosis injury associated with malleolar ankle fracture can be avoided using Weber's three indexes in the mortise view. *Injury*. 2017;48(4):954-959. doi: 10.1016/j.injury.2017.02.004
49. Lampridis V, Gougoulias N, Sakellariou A. Stability in ankle fractures: Diagnosis and treatment. *EFORT Open Rev*. 2018;3(5):294-303. doi: 10.1302/2058-5241.3.170057

50. van den Heuvel SB, Dingemans SA, Gardenbroek TJ, Schepers T. Assessing quality of syndesmotic reduction in surgically treated acute syndesmotic injuries: a systematic review. *J Foot Ankle Surg*. 2019;58(1):144-150. doi: 10.1053/j.jfas.2018.08.038
51. Cehic MG, Jaarsma R, Whitehorn A. Effectiveness of suture button fixation versus screw fixation for the management of acute distal tibiofibular syndesmotic injuries: a systematic review protocol. *JBI Evid Synth*. 2023;21(5):977-984. doi: 10.11124/JBIES-22-00219
52. Mercan N, Yıldırım A, Dere Y. Biomechanical analysis of tibiofibular syndesmosis injury fixation methods: a finite element analysis. *J Foot Ankle Surg*. 2023;62(1):107-114. doi: 10.1053/j.jfas.2022.05.007
53. Wu CC, Yeh WL, Lee PC, et al. Should diastatic syndesmosis be stabilized in advanced pronation-external rotation ankle injuries? A retrospective cohort comparison. *Orthop Surg*. 2022;14(7):1447-1456. doi: 10.1111/os.13331
54. Gafurov FA. Experience of surgical treatment with ruptures of distal tibiofibular syndesmosis. *Bulletin of Science and Education*. 2020;(18):78-80. (In Russ.)
55. Khojaly R, Rowan FE, Hassan M, et al. Weight-bearing allowed following internal fixation of ankle fractures, a systematic literature review and meta-analysis. *Foot Ankle Int*. 2022;43(9):1143-1156. doi: 10.1177/10711007221102142
56. Kingston KA, Lin Y, Bradley AT, et al. Salvage of chronic syndesmosis instability: a retrospective review with mid-term follow-up. *J Foot Ankle Surg*. 2023;62(2):210-217. doi: 10.1053/j.jfas.2022.06.010
57. Selivanov VA, Zhumagulov MO, Omirzak EJ, et al. Arthroscopic syndesmotic repair for syndesmotic injury of ankle. *Vestnik KazNMU*. 2016;3-1:295-300. (In Russ.)
58. Lim SK, Ho YC, Ling SK, Yung PS. Functional outcome of fusion versus ligament reconstruction in patients with a syndesmosis injury: A narrative review. *Asia Pac J Sports Med Arthrosc Rehabil Technol*. 2021;25:53-59. doi: 10.1016/j.asmart.2021.05.002

The article was submitted 25.04.2023; approved after reviewing 27.04.2023; accepted for publication 01.12.2023.

Information about the authors:

Farrukh A. Gafurov – assistant of the department;

Iskandar Yu. Khodzhanov – Doctor of Medical Sciences, Professor, Head of the Clinic, https://orcid.org/0000-0001-9420-3623;

Djalolidin Sh. Mansurov – Candidate of Medical Sciences, Head of the Department, jalolmedic511@gmail.com; https://orcid.org/0000-0002-1799-641X;

Sherzod N. Eranov – Candidate of Medical Sciences, Assistant of the Department, https://orcid.org/0000-0001-6544-5375.

Contribution of the authors:

Gafurov F.A. – conceptualization, validation, investigation, data curation, writing – original draft.

Khodzhanov I.Yu. – methodology, control.

Mansurov D.Sh. – writing – original draft and final draft, formal analysis, project management.

Eranov Sh.N. – writing – original draft, visualization.