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X-ray assessment of the efficiency of hybrid stable-elastic fixation unstable ankle fractures

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The level of complications after treatment of patients with bone fractures stays high 22–60 %. Understanding ankle-foot joint biomechanics is critical for choosing trendy methods hybrid fixation or the traditional fixation of the fibula plate and positional screw for distal syndesmosis. Objective. To analyze the effectiveness of surgical treatment of patients with unstable trans- and suprasyndesmosis fractures with hybrid stable-elastic fixation (HSEF) in comparison with the traditional method of fixation with a bone plate with a positioning screw according to X-ray morphometric parameters. Methods. 82 patients with unstable trans- and suprasyndesmotic fractures of the fibula. The main (I group) of the study consisted of 18 (21,95 %) patients with an average age of (41,6 ± 15,5) years who operated with hybrid stable-elastic fixation, and the control (II group) — 64 (78.05 %) patients with an average age of (52,4 ± 15,7) years, who operated with a bone plate with a positioning screw. Results. The TTA was 0.63 times lower than in patients after traditional fixation. For type C fractures in patients after HSEF, the value of TTA was also 0.78 times (p=0.0005). Conclusions. The analysis of X-ray morphometric parameters of the angle of inclination of the talus bone and the talus-tibia angle confirms the advantage of hybrid stable-elastic fixation in trans- or supra-syndesmotic fractures of the fibula with damage to the distal inter-tibial syndesmosis. According to the value of the index of the angle of inclination of the talus in patients after hybrid stable-elastic fixation, lower risks of ankle-foot joint instability in the p/o period were found than in patients after traditional osteosynthesis. Median values of the talus-tibia angle indicated a tendency to shorten the fibula in patients after traditional osteosynthesis.

Питома вага ускладнень і незадовільних результатів лікування хворих із переломами кісточок залишається високою і сягає 22–60 %. Знання біомеханіки надп'ятково-гомілкового суглоба потребують перегляду, що пов'язано з розробленням нових методів гібридної фіксації. Мета. Провести порівняльний аналіз результатів рентгеноморфометричних показників після гібридної стабільно-еластичної (ГСЕФ) та традиційної фіксації накістковою пластиною з позиційним шурупом нестабільних через- і надсиндесмозних переломів (ЧНСП) малогомілкової кістки з ушкодженням дистального міжгомілкового синдесмозу. Методи. Проаналізовано результати лікування 82 хворих із нестабільними ЧНСП малогомілкової кістки (МГК) типу В і С за Weber із ушкодженням дистального міжгомілкового синдесмозу (ДМГС) за рентгеноморфометричними показниками. Оцінювали кути: нахилу надп'яткової кістки (КННК) і надп'ятково-гомілковий (НГК). У І групі (18 пацієнтів, вік (41,6 ± 15,5) років) виконали ГСЕФ, у ІІ (64, вік (52,4 ± 15,7) років) — остеосинтез МГК с пластиною, ДМГС — позиційним шурупом. Результати. У пацієнтів групи І із переломами типу В показник КННК був у 0,63 разу меншим, ніж в осіб групи ІІ; із переломами типу С — в 0,78 разу (p = 0,0005). Це підтверджує менший ризик нестабільності надп'ятково-гомілкового суглоба в післяопераційному періоді в пацієнтів після ГСЕФ. Наближення медіанного значення НГК до нижньої межі норми виявили у хворих групи І із переломами типу В, до верхньої — в групі ІІ, що свідчить про більшу тенденцію до вкорочення МГК після ГСЕФ. Показник слід ураховувати у хворих з косими (типів В і С за Weber) і, особливо, з уламковими (типів 44 С 2.1, 2.2, 2.3 за АО) переломами МГК, виконуючи ГСЕФ. Висновки. За рентгеноморфометричними показниками кута нахилу надп'яткової кістки та надп'ятково-гомілкового кута доведено перевагу гібридної стабільно-еластичної фіксації для лікування через- або надсиндесмозних переломів малогомілкової кістки з ушкодженням дистального міжгомілкового синдесмозу. Ключові слова. Рентгенологічна діагностика, гібридна стабільно-еластична фіксація, переломи кісточок гомілки, міжгомілковий синдесмоз.

Key words. X-ray assessment, hybrid stable-elastic fixation, unstable ankle fracture, tibiofibular syndesmosis

Introduction

Traumatized patients with a combination of unstable bone fractures and damage to the distal intertibial syndesmosis (DITS) are considered especially difficult in terms of diagnosis and treatment. More than 50 % of such injuries occur in people of working age (from 30 to 60 years old), often as a result of high-energy injury mechanisms, during active participation in various sports [1, 2–5]. The specific weight of complications and unsatisfactory results of treatment of patients with bone fractures remains high and reaches 22–60 % [6–9]. One of the reasons for this is the early onset and rapid progression of osteoarthritis of the talocrular joint (TCJ) in 3.4 % of the population, of which 70–80 % is post-traumatic [10, 11].

A differentiated approach to choosing the optimal treatment tactics depends significantly on established signs of damage instability [12]. Detecting instability in some cases is difficult [13], which sometimes leads to an inadequate solution, and errors in the choice of surgical method of treatment can cause unsatisfactory results [14, 15].

Detection of clinical and radiological signs of damage to the bones of the tibia is mostly not difficult, but the rupture of DITS using conventional diagnostic methods (objective examination, X-ray) — on the contrary [16, 17]. About 45 % of DITS ruptures are diagnosed intraoperatively during a gravity test, «hook test», or «tap test», which are performed under the control of a fluoroscope [16–22]. At the same time, findings of computed tomography (CT) [23], magnetic resonance imaging (MRI) [24–26], and X-ray morphometric measurements [27] should be taken into account. Deviation of the fibular bone (FB) by 1 mm or an increased distance between the tibia and fibula bones of more than 5 mm revealed by radiography is a reason for discussion among clinicians due to the formation of misconceptions about the absence of DITS damage [28, 30].

The use of modern X-ray morphometric parameters makes it possible to determine the degree of injury to the bone and soft tissue components of the TCJ at the stage of diagnosis. Modern mobile X-ray devices enable intraoperative monitoring during the restoration of structures of the TCJ, the correctness of the use of modern stabilizing structures [31].

Usually, the treatment of patients with unstable bone fractures and DITS damage is traditional with stabilization of the FB with a bone plate and restoration of the DITS with a positional screw [32, 33]. But the deepening of knowledge about the biomechanics of the TCJ in the norm revealed the peculiarities of the rotational movement of the FB during the loading process [34, 35]. This led to a revision of the traditional use of a bony fixator and a positional screw, which, albeit temporarily, immobilizes the dynamic structure of DITS [36]. Violation of the principles of DITS repositioning leads to complications in 12–52 % of cases [37]. Currently, the postulates of DITS stabilization with positioning screws are being revised [38]. Some biomechanical studies have proven the possibility of independent use of tape on endobatons for DITS fixation without a positional screw with a satisfactory rehabilitation result [39].

We proposed a hybrid method of stabilizing the FB with an intramedullary nail, and the damaged DITS with a tie tape, which we called «hybrid stable-elastic fixation» (HSEF) [40]. But each of the new fixatives requires a corresponding update of the knowledge of X-ray morphometric parameters, which would testify to the adequacy of the restoration of the components of the TCJ. The correctness of the proposed combined fixation (HSEF) needs scientific proof.

Purpose: to conduct a comparative analysis of the results of X-ray morphometric indicators after hybrid stable-elastic and traditional fixation with a bone plate with a positional screw of unstable trans- and suprasyndesmotic fractures of the fibula with damage to the distal intertibial syndesmosis.

Material and methods

The clinical studies submitted for publication were approved by the local Ethics Committee at Ivano-Frankivsk City Clinical Hospital No. 1 (protocol No. 85 dated 29.03.2018). Patients who were involved in the study signed an informed consent.

The analysis of the X-ray morphometric parameters of the angle of inclination of the talar bone and the talocrural angle was performed after HSEF and traditional fixation with a bone plate with a positional screw in 82 patients with unstable trans- and suprasyndesmosis (types B and C according to Weber) fractures (TSSF) of the fibula with DITS damage, who were treated in inpatient trauma departments of clinical hospitals in Ivano-Frankivsk from 2018 to 2021. Among them there were 46 (53.7 %) women, 38 (46.3 %) men. The majority (68.3 %) of patients were of working age from 21 to 60 years old. Radiological examination was performed in standard direct and

lateral projections during preoperative planning and in the postoperative period using a stationary digital device Opera RT20 (GMM, Italy) and a mobile device of the C-arm type, Radius (International Medical Devices, England).

The main group I consisted of 18 (21.95 %) patients, average age (41.6 ± 15.5) years, who underwent HSEF of the FB with a blocked intramedullary nail for the long bones of the forearm (CHARFIX system® company), and DITS injuries with an elastic bandscreed (ARTREX® FiberWire®) No. 5 on endobatons. The control (II) group included 64 (78.05 %) individuals, average age (52.4 ± 15.7) years, who underwent traditional osteosynthesis of a fracture of the FB with a plate with fixation of the damaged DITS with a positioning screw, which had to be removed 6–8 weeks after surgery.

By the features of damage to anatomical structures according to the AO classification, the patients were divided as follows: the main group — 22 % of patients had type 44 B1 fractures (in particular, 44 B1.2), 22 % — type 44 B2, which included 44 B2.1, 34 % — 44 In 2.2, 22 % — type 44 B3 (11 % of subtypes 1 and 2 each); control group — 8 % of people with type 44 B 1.2 fractures, 22 % and 32 % — type 44 B2 (subtypes 1.2 and 2.2, respectively), type 44 B3 (only subtype 44 B3.2) — 38 %. Patients with type 44 C fractures in the comparison groups were distributed as follows: main — 22 % with type 44 C1 fractures (11 % of subtypes 1.1, 1.3 each), 22 % — 44 C2 (11 % of subtypes 2.1 and 2.2 each), 56 % — type 44 C2.3. Among the patients of the II (control) group with type 44 C1.1 fractures, there were 30 % of people, 44 C 1.2 and 1.3 — 15 %, respectively, 44 C2.1 — 7 %, 44 C2.2 — 11 %, 44 C2.3 — 18 %, 44 C3.3 — 4 %. Thus, groups I and II were homogeneous in terms of age, sex, and type of fracture.

Evaluation of all X-ray morphometric parameters was used to determine treatment tactics, preoperative planning, and postoperative control of osteosynthesis in certain periods (within 1–2 days after surgery, before removal of the positioning screw in patients of the control group or as clinically necessary). In the postoperative period, on control radiography of the TCJ in standard projections, measurements were taken into account in comparison with known normal values.

The study involved determination of the following:

1. *Talocrural angle* (TCA) — between the distal surface of the tibia and the line between the tops of the medial and lateral bones, which has acceptable values of 83° ± 4° and is used for comparison with structures on the opposite side. The parameter is valuable for determining the adequacy of restoration of the length of the FB;

2. *Talar tilt angle* (TTA) — forming lines that run parallel to the talar bone and to the distal edge of the tibia, which should not exceed 2°. An increase in the angle indicates medialization or lateralization, that is, instability of the TCJ.

The statistical processing of the obtained results was carried out in accordance with the rules of medical and biological statistics using MS Excel and Statistica 6 software. The method of non-parametric statistics was applied – the paired Mann-Whitney U Test for independent populations.

Results and their discussion

Evaluation of the median values of the talocrural angle revealed acceptable indicators in the comparison groups that did not go beyond the normal range (N = 83° ± 4°).

As a result of measuring the tilt of the line between the tops of the inner and outer bones, which probably indicates a violation of the congruence of the structures of the TCJ after surgical restoration of the length of the FB, significant differences were found in patients with type B and C fractures of the FB (according to Weber) in the comparison groups (Fig. 1).

The tendency to the shortening of the FB was determined by the approximation of the median value of the TCA (83.5° [79.2°–85.2°]) in patients of group I (main) to the lower limit of the norm (79°–87°) under the conditions of type B fractures. In patients with type C fractures, the value of the TCA was 82.5° [79.1°–85.1°]. Median values of TCA in patients of the II (control) group were closer to the upper limit of the norm ($p = 0.0366$). This indicated the danger of shortening of the FB, which should be considered after closed reduction at the stage of nail implantation for HSEF, especially in patients with comminuted (types 44 C2.1, 2.2, 2.3) and oblique fractures of the FB (types B and C).

The length of the FB at this stage was restored with the intraoperative use of a distractor and proximal locking with a locking screw inserted perpendicular to the intramedullary canal of the FB above the tip of the nail.

An increase (over 2°) in the TTA is known to indicate a deviation (medialization or lateralization) of the talar bone in the «fork» of the TCJ. According to the median values of the TTA index, an excess of 2° was not established in any of the patients with types B and C fractures (a clinical example of a patient of group I is shown in Fig. 2).

However, a significant difference in the median value of the TTA indicator was found in patients of the comparison groups with fractures of types B

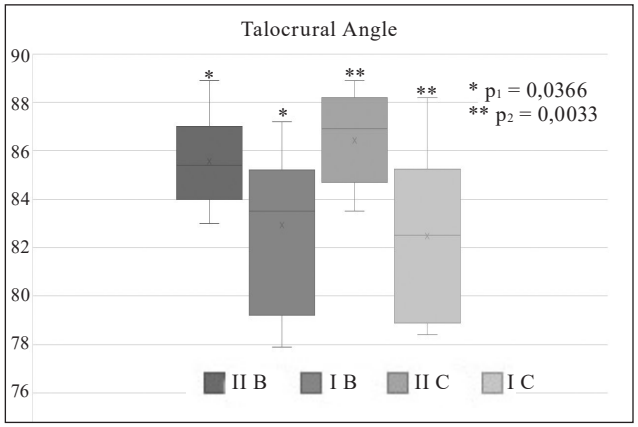

Fig. 1. Comparative results of the median values of the radiometric value of TCA (N = 83° ± 4°) in the study groups on control radiography after surgery (degrees)

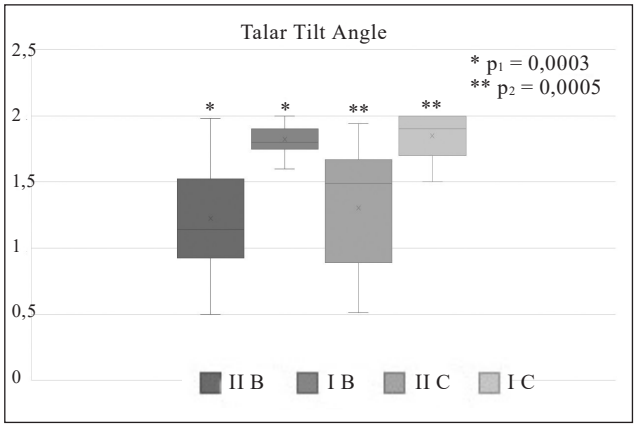

Fig. 3. Comparative results of the median values of the radiometric value of TTA (N ≤ 2°) in the study groups on control radiography after surgery (degrees)

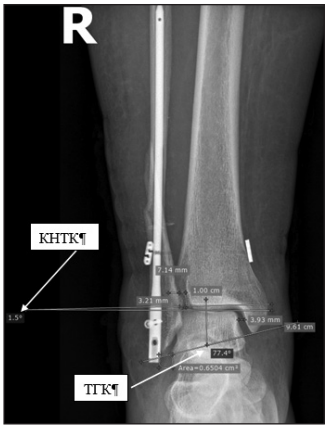

Fig. 2. X-ray morphometric indicators of TCA and TTA in patient X. (group I) with a type 44 C1.2 fracture after HSEF

and C (Fig. 3). In particular, in individuals of group I with a type B fracture, the TTA index (1.14° [0.94°–1.48°]) was 0.63 times lower than in group II (1.8° [1.8°–1.9°], p = 0.0003). In the case of diagnosed type C fractures in patients of the I group, the TTA was equal to 1.49° [0.89°–1.67°] and was also 0.78 times smaller (p = 0.0005) compared to the II group — 1.9° [1.7°–2°]

Of course, the risk of instability may rise as TTA increases. We established that this risk is lower in patients of group I compared to group II. Therefore, according to the TTA indicators following HSEF with a nail and a tie-tape (group I), we ascertained the superiority of this method for stabilization of the TCJ over the use of a plate for fixation of the FB with rigid positioning of the DITS screw (group II).

Conclusions

Evaluation of X-ray morphometric parameters of the talocrural angle and the angle of inclination of the supracalcaneal bone proved the advantage of hybrid stable-elastic fixation in trans- or supra-syndesmotic fractures of the fibula with damage to the distal inter-tibial syndesmosis.

The median value of the talocrural angle index in most patients with types B and C fractures after hybrid stable-elastic fixation was close to the lower limit of normal, after osteosynthesis with a plate with a positional screw to the upper limit, which indicated a greater tendency in them to shorten fibula bone. This indicator should be taken into account in persons with oblique (types B and C) and, especially, comminuted (type 44 C2.1, 2.2, 2.3) fractures of the fibula during hybrid stable-elastic fixation and restore the length of the fibula with the intraoperative use of a distractor and proximal locking with a locking screw above the top of the nail.

According to the value of the index of the angle of inclination of the talar bone in patients after hybrid stable-elastic fixation, a lower risk of instability of the talocrural joint in the postoperative period was found than in patients after traditional osteosynthesis.

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

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X-RAY ASSESSMENT OF THE EFFICIENCY OF HYBRID STABLE-ELASTIC FIXATION UNSTABLE ANKLE FRACTURES

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