

Surgical complications of intra-articular calcaneal fracture treatment

Powikłania leczenia operacyjnego złamań stawowych kości piętowej

Piotr Golec ^{1(A,B,C,E,F)}, Krzysztof A. Tomaszewski ^{1,2(B,C,D)}, Sebastian Nowak ^{1(B,D,F)},
Zbigniew Dudkiewicz ^{3(B,E,F)}

¹ Department of Trauma and Orthopaedic Surgery, 5th Military Clinical Hospital with Polyclinic in Krakow, Poland

² Faculty of Anatomy, Jagiellonian University Collegium Medium in Krakow, Poland

³ Hand Surgery Clinic, Department of Orthopedics and Traumatology, Medical University in Lodz, Poland

Key words

intra-articular calcaneal fractures, complications

Abstract

Introduction: The authors present complications following surgical treatment of intra-articular calcaneus fractures, in regards to the surgical technique employed, based on their own clinical material.

Materials and methods: The techniques analyzed included the Westhues' technique and its modification with additional bone stabilization by Kirschner wires and the percutaneous stabilization by Rapala. The research material covered the years from 1990 to 2012 and consists of 82 operated patients - 68 men (83%) and 14 women (17%). Analyzed calcaneus fractures were divided using the Essex-Lopresti classification.

Results: The authors of the article indicate that the most frequently registered complications of surgical treatment of intra-articular calcaneus fractures in early observation were thromboembolic complications and local inflammatory reactions of the skin at the point of incision and placing the stabilizing material. During the long-term follow-up, the post-thrombotic syndrome and algodystrophic disorders were the most common.

Conclusions: Factors contributing to the occurrence of the complications registered were fracture morphology, fixation of bone fragments by an excessive number of stabilizing materials and prolonged immobilization of the operated limb.

Słowa kluczowe

złamania stawowe kości piętowej, powikłania

Streszczenie

Wstęp: Autorzy pracy prezentują zarejestrowane w materiale własnym powikłania leczenia operacyjnego złamań stawowych kości piętowej z wykorzystaniem różnego rodzaju materiałów zespalających.

Materiały i metody: Analizowanymi technikami operacyjnymi były zespolenie Westhuesa oraz jego modyfikacja z dodatkową stabilizacją odłamów kostnych drutami Kirschnera, a także przezskórna stabilizacja sposobem Rapala. Materiał badań obejmuje lata od 1990 do 2012 roku, a stanowi go 82 operowanych, w tym 68 mężczyzn (83%) i 14 kobiet (17%). Analizowane złamania kości piętowej klasyfikowano w oparciu o podział Essex-Lopresti.

Wyniki: Autorzy pracy zwracają uwagę, że najczęściej rejestrowanymi powikłaniami leczenia operacyjnego złamań stawowych kości piętowej w obserwacji wczesnej są powikłania zakrzepowo-zatorowe oraz miejscowy odczyn zapalny skóry w miejscu wprowadzenia do kości materiału zespalającego, a w obserwacji odległej zespół pozakrzepowy i zaburzenia algodystroficzne.

Wnioski: Czynnikiem sprzyjającym występowaniu tych powikłań jest morfologia samego złamania, zespolenie odłamów kostnych nadmierną liczbą elementów materiału zespalającego oraz długotrwałe unieruchomienie kończyny operowanej.

The individual division on this paper was as follows: a – research work project; B – data collection; C – statistical analysis; D – data interpretation; E – manuscript compilation; F – publication search

Article received: 01.05.2016; accepted: 01.09.2016

Please cited: Golec P., Tomaszewski K.A., Nowak S., Dudkiewicz Z. Surgical complications of intra-articular calcaneal fracture treatment. Med Rehabil 2016; 20(2): 25-30

Internet version (original): www.rehmed.pl

INTRODUCTION

Traumatic injuries to the feet are one of the most frequently recorded in everyday clinical practice. These include fractures of the calcaneus which, according to Eastwood and Atkinas¹ and Lim and Leung² and others, account for 60-65% of all tarsal bone fractures, and about 2% of all traumatic damage to the locomotor system. Fractures are primarily the result of sudden axial impact of high-energy traumatic forces on the hind-foot characteristic, among others, for traffic accidents or falls from heights. This state is recorded

primarily in men between the age of 30 and 60^{3,4}. The complex morphology of intra-articular calcaneal fractures results from, inter alia, placement of the foot at the moment of action of the trauma forces, the biological value of bone tissue and is dependent on a number of different kinds of systemic changes characteristic for the age of the victims, blood flow disorders, individual susceptibility or the use of medicine or drugs. The radiographic image of these fractures is dominated by extensive damage to the articular surface of the subtalar joint and the talocalcaneonavicular joint with

changes in the value of the Böhler angle, the Gissen angle or path of the Mc Laughlin line⁵⁻⁸ (Figure 1). For the diagnosis of intra-articular fractures of the calcaneus, a number of methods are used, including, in particular, radiographs taken from the lateral and axial projection³, CT^{9,10} or MRI¹¹. In the imaging of the described fractures, the method of volumetric transformations is also frequently used¹² (Figure 2). Treatment of calcaneus intra-articular fractures is a real challenge for many reasons, and the currently preferred surgical treatment is not always perceived as successful¹³⁻¹⁶.



Figure 1
X-rays of the calcaneus from lateral view with indicated a) Bohler's angle b) Gisseane's angle c) McLaughlin's line



Figure 2
3D imaging of a crush-type fracture of the left calcaneus using the method of volumetric transformations – medial view

STUDY AIM

The aim of this study was to determine the most common complications due to surgical treatment of intra-articular calcaneus fractures, including answering the following questions:

1. What are the most frequently recorded complications of intra-articular calcaneal fractures depending on their morphology and the method used for fixation of bone fragments in the early and long-term follow-up periods?
2. Which of the intra-articular calcaneal fractures, treated surgically using the analyzed methods, are at risk of the occurrence of certain complications both in early and long-term follow-up periods?
3. What are the factors conducive to the occurrence of the analyzed complications due to surgical treatment of intra-articular calcaneal fractures?

STUDY MATERIAL

The aim of the study was formulated on the basis of the material coming from the Department of Trauma and Orthopaedic Surgery, 5th Military Clinical Hospital with Polyclinic - Independent Public Health Care Centre in Krakow (5WSK), covering the period 1990-2012. The division of the research material was carried out based on the criteria of the gender of the surgical patients, their age, type of sustained fractures using the Essex-Lopresti classification¹⁷, the method of fixation of bone fragments and registered complications. 82 participants operated on due to inter-articular calcaneal fractures were selected for the study, including 68 men, representing 83% of all subjects, and 14 women, or 17%. The age of the enrolled subjects on

ing the Essex-Lopresti¹⁷ classification in the evaluation of the analyzed fractures, men were diagnosed with tongue-type fractures in 26 of the subjects, that is 31.7%, and crush-type fractures in 42, which is 51.3%. In women, however, tongue-type fractures were diagnosed in 3 subjects, i.e. 3.6% and crush fractures in 11, which is 13.4%. Therefore, the total of 29 tongue-type fractures were diagnosed in the operated patients, thus 35.3%, and crush-type fractures in 53 of them, representing 64.7%. The reasons for the occurrence of the analyzed fractures are shown in Table 1.

In total, falls from a height of less than 2 meters were the cause of fractures in 19 of the studied victims, which accounts for 23.1%, a fall from a height of over 2 meters in 39 of them, or 47.7%, traffic accidents – in

method of percutaneous fixation of bone fragments with Kirschner wires using Rapala’s method in 15 subjects, giving 18.3%. In women, however, in the treatment of tongue-type fractures, the Westhues method enriched with Kirschner wires was used in 3 subjects, i.e. 3.6%. In the treatment of crush fractures for 4 of the patients, or 4.8%, the Westhues method using Kirschner wires was used, and Rapala’s method – in the remaining 7, thus 8.5%.

All participants included in the study were operated on after 2-6 days following the fracture. The surgery was performed under spinal or epidural anesthesia. In patients who underwent fixation of bone fragments using the Westhues method, the operated limb was immobilized in a short leg cast for a period of 6 to 8 weeks. At that time, prevention of thromboembolism using low molecular heparin and antibacterial prophylaxis in accordance with applicable principles and guidelines (Zinacef, Biodacyna, Tarcefandol) was implemented. Steinmann nails and Kirschner wires were removed from the operated calcaneal bone on the day of removing the cast. In some of the operated patients, after the removal of the cast, an empty-heel cast was put on for another 2 weeks. Physiotherapy treatment of the operated limb began 1-2 weeks after the removal of the bonding material and included a magnetic field, hydro-air massage therapy, local cryotherapy as well as passive and active exercises to improve the foot joints range of motion. For this purpose, among others, the Artromot CPM device (Continuous Passive Motion method) has been used since 1998. Attempts at gradual progressive weight-bearing were taken between 10 to 12 weeks after the day of surgery.

STUDY METHODS

The research method is based on the observation of clinical registrations of complications in the perioperative period up to 3 months from the date of performing the surgery, which was adopted as the early observation pe-

Table 1
Causes of analyzed calcaneal fractures.

| Causes of fractures | Sex | | | |
|------------------------|-------|------|---------|-----|
| | Males | | Females | |
| | No. | % | No. | % |
| Fall from height < 2 m | 12 | 14.6 | 7 | 8.5 |
| Fall from height > 2 m | 37 | 45.3 | 2 | 2.4 |
| Traffic accident | 11 | 13.4 | 5 | 6.1 |
| Parachute jump | 8 | 9.7 | - | - |
| Total | 68 | 83 | 14 | 17 |
| m - meter | | | | |

the date of surgery ranged from 34 to 67 years and averaged 48 years, including men aged 34 to 53, with an average of 41 years, and women from 61 to 67, which gives an average of 64 years.

In men right-side fractures of the calcaneus were diagnosed in 47 subjects, thus 57.4%, and the left calcaneus in the remaining 21 subjects, or 25.6%. Among women, right calcaneus fractures were diagnosed in 8 subjects, which accounts for 9.7%, and the left calcaneus in the remaining 6, which equals 7.3%. In total, right calcaneus fractures were diagnosed in 55 of the subjects, i.e. 67.1%, and the left calcaneus fractures in the remaining 27 participants, accounting for 32.9%. Assum-

16 operated patients, or 19.5%, parachute jumps – 8, which is 9.7%.

In the treatment of tongue-type fractures, surgical treatment based on the fixation of the bone fragments was applied using the Westhues method or the Westhues method with additional stabilization of bone fragments with Kirschner wires. The Westhues method was applied in 19 men, accounting for 23.2%, and the Westhues method along with additional stabilization using Kirschner wires in 7 of them, namely, 8.6%. In this group, thus in men, the surgical treatment of crush-type fractures included the Westhues method with additional stabilization of the bone fragments with Kirschner wires in 27 of the subjects, that is 32.9%, and the

riod and up to 6 months after treatment, which was established as the long-term follow-up period.

The obtained results were subjected to statistical analysis, which was performed using the Statistica 10 PL (StatSoft) statistical software. Data presentation includes elements of descriptive statistics (percentage distribution, mean value). The type of data distribution was assessed using the Shapiro-Wilk test. In the case of normal distribution of variables, the t-test was used to compare the groups, and in the absence of normal distribution – the U Mann-Whitney test. Similarly, to evaluate the correlation between the variables, Pearson's r correlation coefficient was used. The statistically significant level was assumed as $p < 0.05$.

RESULTS

The results obtained during the early period of observation

In men after surgical treatment of tongue-type intra-articular fractures of the calcaneus using the Westhues method of fixation complications in the form of deep vein thrombosis (DVT), local inflammatory reaction in the entry area of the Steinmann nails from the side of the calcaneal tuberosity and its destabilization were reported. Below knee DVT of the operated limb was diagnosed in 2 patients operated on using this method, which is 3%, local inflammation of the skin in area of Steinmann nail entry from the side of the calcaneal tuberosity was diagnosed in 4 of them, that is 5.9%, and the destabilization of anastomosis - in 1, which gives 1.4%. In total, in men operated on using the Westhues method during the early follow-up period, complications were observed in 7 patients, i.e. in 10.3% of patients operated on this way. In the early observation period, in the men operated on the Westhues method in combination with further stabilization of bone fragments using Kirschner wires, below knee deep vein thrombosis was recorded in 3 subjects, i.e. 4.4%, and local inflammation at the

point of entry of Steinmann nails also in 3 subjects, thus 4.4%. Altogether, given this method of intra-articular calcaneal fractures treatment in males in the early follow-up period, complications were diagnosed in 6 of them, which gives 8.8%. In the same period of observation in men who were treated surgically for crush calcaneus fractures using the Westhues method with additional stabilization of bone fragments with Kirschner wires, below knee deep vein thrombosis was recorded in 2 cases, which gives 3%, and local inflammation of the skin at the point of entry of the fixation material occurred in 4 patients, i.e. 5.9%. Application of the Rapala method in this group of patients resulted in below knee DVA of the operated limb in 3 men, or 4.4%, and in 5 of them, or 7.3% - a local inflammatory reaction of the skin at the point of entry of the fixation material. In total, in the early period of observation, complications were noted in 12 cases, accounting for 20.6% in the men who underwent surgery for crush calcaneus fractures.

In total, males surgically treated using the above mentioned methods, in the early follow-up period, were diagnosed with the discussed complications in 27 cases, accounting for 39.7% of all men and 32.9% of the study group; including vein thrombosis observed in 10 patients, 14.8%, and local inflammatory complications - 16 cases, which gives 23.5% and in 1 subject, destabilization of the fixation, which is 1.4%.

In men during the early follow-up period, below knee deep vein thrombosis of the surgically treated limb coexisted with local inflammatory reaction of the skin in 7 patients, i.e. 10.3%. In this group, 4 men with crush fractures were treated using the Westhues method in combination with further fixation of the bone fragments using Kirschner wires, which is 5.9%, the next 2 were treated for crush fractures using the Rapala method, giving 3%, and 1 man was treated for tongue-type fractures with the Westhues method, totaling 1.4%.

In men in the early period of observation, there were no statistically significant differences between the

incidence of postoperative complications, depending on the type of fracture and method used for fixation of the bone fragments ($p > 0.05$).

In women surgically treated for tongue-type fractures using the Westhues method combined with further fixation of bone fragments using Kirschner wires, deep vein thrombosis of the operated limb was diagnosed in 2 cases, i.e. in 14.3% of the study participants during the early follow-up period. In women treated surgically for crush fractures with the Westhues method in combination with further fixation of bone fragments using Kirschner wires, deep vein thrombosis of the operated limb was diagnosed in 2 study participants as well, which also equals 14.3%, and in the same group (crush-type) treated using Rapala's method, 3 patients were diagnosed with DVA, which gives 21.4%, and local inflammation of the skin in the place of fixation material entry in 4, thus 28.6%. Below knee deep vein thrombosis of the operated limb coexisted with local inflammatory reactions of the skin in the place of entry of Kirschner wires bundle in 6 of the operated women, which is 42.8%, including 4 patients, or 28.6% treated for crush fractures using the Westhues method along with further fixation of the bone fragments using Kirschner wires and in 2, or in 14.3%, treated for the same reason using the Rapala method.

In the group of women in the early period of observation, there were no statistically significant differences between the incidence of postoperative complications depending on the type of fracture or method of bone fragment fixation ($p > 0.05$).

In the early follow-up period, there were no statistically significant differences between the incidence of types of postoperative complications between men and women ($p > 0.05$).

The results obtained during the long-term follow-up period

Men operated on due to intra-articular fractures of the calcaneus in the follow-up period were diagnosed with complications in the form of

post-thrombotic syndrome of shin in the operated limb, local skin necrosis at the point of fixation material entry, which developed on the basis of earlier inflammatory changes and Sudeck syndrome.

In men, during the long-term observation period, post-thrombotic syndrome of the operated limb was diagnosed in 3 subjects, i.e. 4.4%, in 1 subject (which gives 1.4%), co-existing local skin necrosis at the point of entry of Steinmann nails developed on the basis of pre-existing inflammatory conditions. The patient was operated on because of a crush fracture using the Westhues method and additional stabilization of bone fragments with Kirschner wires.

Sudeck syndrome was diagnosed in 2 men in the long-term follow-up period, thus 3%, who were operated on because of the crush fractures, including 1 using the Westhues method with additional stabilization of bone fragments using Kirschner wires and in 1, surgically treated using the Rapala method.

In the long-term observation period, in 2 women (i.e. 14.3% of the analyzed cases) after surgical treatment of tongue-type fractures using the Westhues method in combination with further stabilization of bone fragments using Kirschner wires, below knee deep vein thrombosis of the operated limb was noted. In women treated surgically for crush fractures using the Westhues method in combination with additional stabilization of bone fragments using Kirschner wires, 1 case was diagnosed with below knee deep vein thrombosis of the operated limb, which gives 7.1%, whereas in subjects treated using the Rapala method in the same group of fractures (crush) 2 such cases were noted, giving 14.3%. During the long-term follow-up of the studied women, Sudeck syndrome was noted in 2 cases, i.e. 14.3% of patients treated because of tongue-type fractures using the Westhues method with further stabilization of bone fragments via Kirschner wires. Inflammatory complications were not noted during the follow-up period in the examined group of women.

DISCUSSION

Intra-articular fractures of the calcaneus are the subject of constant interest in the environment of traumatologists, as a special group of traumatic damage to the musculoskeletal system, the treatment of which is burdened with significant complication and failure rates^{18,19}. This state of affairs is influenced by many factors perceived both in the early and long-term follow-up periods. With certainty, they include morphology of the fracture, particularly comminuted and crush fractures, sparse coverage of the lateral and medial surface of the heel by skin, which promotes the generation of necrosis and inflammatory reactions¹³, prolonged immobilization of a limb after surgery or during non-operative treatment²⁰⁻²².

The proposed methods of surgical treatment of calcaneus intra-articular fractures are associated with varying degrees of skin damage to the heel, and thus - with the possibility of creating complications in the form of necrosis or local inflammatory reactions at the point of entry of the fixation material to the bone or in the surgical wound. This is undoubtedly the lateral access to the calcaneus with the fixation of the bone fragments using various types of plates^{1,23}, but also minimally invasive fixation or transdermal fixation²⁴⁻²⁶, which include, inter alia, fixation using the Westhues³ and Rapala⁵ methods. According to Zwippa et al.²⁷, superficial necrosis of the surgical wound is present in 8% of patients treated surgically because of calcaneus intra-articular fractures, and surgical wound infections - in 1.2% of them. The data presented by Makki et al.²⁸ indicate that complications due to surgical treatment of calcaneus intra-articular fractures using lateral approach are found in 10.6% of cases. Similar data can be found in the publication by Zeman et al.¹³ who reported various types of complications following surgical treatment of calcaneus intra-articular fractures during the early period of observation in 20.7% of patients, including necrosis of the surgical wound in 6.9% of them, while Zhang²⁹ ob-

served delayed surgical wound healing because of inflammation in 8.1% of studied patients.

These data do not substantially differ from the data noted in our own study. However, they draw attention to the occurrence of thromboembolic surgical complications in the early period of observation, which in some cases, resulted in postthrombotic syndrome during the long-term follow-up period and to the need for further vascular treatment. Long-term observation also showed bone demineralization including Sudeck syndrome, the cause of which can be seen in long-term immobilization of the operated limbs. The occurrence of cold and blue skin in these patients, accompanied by pain especially in the hindfoot, were of algodystrophic nature³⁰. Apprehension towards destabilization of the fixation especially in comminuted and crush fractures results in the conviction of the essential long-term immobilization of a limb, which not only increases the risk of bone tissue demineralization, but also leads to thromboembolic changes and impaired bone healing due to reduced blood flow. Based on the analysis of our own material, we are inclined to opt for the position that complications - inflammatory, thromboembolic and necrosis of soft tissue, after surgical treatment of calcaneus intra-articular fractures - are conducive to the nature of the fixation material, both in terms of quantity and quality. In other words - the more material is used for fracture fixation, the greater the risk of these complications.

CONCLUSIONS

1. The most frequently recorded complications of surgical treatment of calcaneus intra-articular fractures occurring in the early follow-up period are thromboembolic complications and local inflammatory reactions of the skin at the point of entry of bone fixation materials. During the follow-up observation, however, postthrombotic syndrome and algodystrophic disorders can be noted.

2. The most susceptible to the occurrence of complications due to surgical treatment of calcaneus intra-articular fractures are crush-type fractures according to the Essex-Lopresti classification.
3. Factors favoring the occurrence of complications due to surgical treatment of intra-articular fractures of the calcaneus include the morphology of the fracture itself, fixation of bone fragments with an excessive number of fixation elements and long-term immobilization of the operated limb.

Conflict of interest: none

References

1. Eastwood D.M., Atkins R.M. Lateral approaches to the heel. A comparison of two incisions for the fixation of calcaneal fractures. *Foot* 1992; 2: 143-147.
2. Lim E.V.A., Leung J.P.F. Complications of intra-articular calcaneal fractures. *Clin Orthop* 2001; 391: 7-16.
3. Golec E., Nowak S., Goździalski R., Godyń M. Odległe wyniki leczenia złamań stawowych kości piętowych sposobem Westhuesa. *Chir Narz Ruchu Ortop Pol* 2003; 68(3): 185-189.
4. Coughlin M.J. Calcaneal fractures in the industrial patient. *Foot Ankle Int* 2000; 21: 896-905.
5. Rapala K., Remiszewski A., Walkiewicz A. Ocena odległa wyników 80 stawowych złamań kości piętowej leczonych różnymi sposobami. *Wiad Lek* 1992; 55(17-18): 693-696.
6. Rapala K. 30 lat doświadczeń dotyczących leczenia 150 stawowych złamań kości piętowych. *Chir Narz Ruchu Ortop Pol* 1998; 63(5): 407-412.
7. Schepers T., Heetveld M.J., Mulder P.G.H., Patka P. Clinical outcome scoring of intra-articular calcaneal fractures. *J Foot Ankle Surg* 2008; 47(3): 213-218.
8. Rapala K., Truszczyńska A. Articular fractures of calcaneus. *Pol Przegl Chir* 2010; 82(4): 233-242.
9. Sanders R., Fortin P., DiPasquale T., Walling A. Operative treatment in 120 displaced intra-articular calcaneal fractures. Results using a prognostic computed tomography scan classification. *Clin Orthop* 1993; 290: 87-95.
10. Daftary A., Haims A.H., Baumgaertner M.R. Fractures of the calcaneus: a review with emphasis on CT. *Radiographics* 2005; 25(5): 1215-1226.
11. Grala P., Mychyńska-Bučko Z., Kierzyńska G. Radiographic imaging of calcaneal fractures – the surgeons view point. *Pol J Radiol* 2007; 72(2): 88-91.
12. Eckard H., Lind M. Effect of intraoperative three-dimensional imaging during the reduction and fixation of displaced calcaneal fractures on articular congruence and implant fixation. *Foot Ankle Int* 2015; 36(7): 764-773.
13. Zeman P., Zeman J., Matejka J., Kudela K. Long-term results of calcaneal fracture treatment by open reduction and internal fixation using a calcaneal locking compression plate from an extended lateral approach. *Acta Chir Orthop Traumatol Cech* 2008; 75(6): 457-464.
14. Wang B.S., Chen X.M., Pang C., Yu H.L., Wang L. Surgical treatment for intra-articular calcaneal fractures. *Zhongguo Gu Shang* 2012; 25(11): 957-959.
15. Rammelt S., Zwipp H. Fractures of the calcaneus; current treatment strategies. *Acta Chir Orthop Traumatol Cech* 2014; 81(3): 177-196.
16. Kinner B., Kerschbaum M., Bley C., Spiegel A., Roll C. Bionic plate design for calcaneal fracture treatment. A biomechanical analysis and first clinical results. *Int Orthop* 2015; 39(1): 11-17.
17. Essex-Lopresti P. Mechanism, reduction technique and results in fractures of os calcis. *Br J Surg* 1952; 39: 395-419.
18. Grala P., Mańkowski B., Machyńska-Bučko Z. Powikłania przemieszczonych złamań kości piętowej. *Ortop Trauma Rehabil* 2007; 2(6): 198-205.
19. Lim E.V.A., Leung J.P.F. Complications of intra-articular calcaneal fractures. *Clin Orthop* 2001; 391: 7-16.
20. Griffin D., Parsons N., Shaw E., Kulikov Y., Hutchinson C., Thorogood M. et al. Operative versus non-operative treatment for closed, displaced, intraarticular fractures of the calcaneus: randomized controlled trial. *BMJ* 2014; 349: g4483. doi:10.1136/bmj.g4483.
21. Barei D.P., Bellabarba C., Sangeorzan B.J., Benischke S.K. Fractures of the calcaneus. *Orthop Clin North Am* 2002; 33: 263-285.
22. Brauer C.A., Mannus B.J., Ko M., Donalds C., Buckley R. An economic evaluation of operative compared with nonoperative management of displaced intra-articular calcaneal fractures. *J Bone Jt Surg* 2005; 87A(12): 2742-2749.
23. Mostafa M.F., El-Adl G., Hassanin E.Y., Abdellatif M.S. Surgical treatment of displaced intra-articular calcaneal fracture using a single small lateral approach. *Strat Traum Limb Recon* 2010; 5: 87-95.
24. Levine D.S., Helfet D.L. An introduction to the minimally invasive osteosynthesis of intra-articular calcaneal fractures. *Injury* 2001; 32: 51-54.
25. Tornetta P. Percutaneous treatment of calcaneal fractures. *Clin Orthop* 2000; 375: 91-96.
26. Schepers T., Schipper I.B., Vogels L.M.M., Ginal A.Z., Mulder P.G.H., Heetveld M.J. et al. Percutaneous treatment of displaced intra-articular calcaneal fractures. *J Orthop Sci* 2007; 12: 22-27.
27. Zwipp H., Tscherne H., Wulker N., Grote R. Intra-articular fractures of the calcaneus. Classification, assessment and surgical procedures. *Unfallchir* 1989; 92(3): 117-129.
28. Makki D., Alnajjar H.M., Walkay S., Ramkumar U., Watson A.J., Allen P.W. Osteosynthesis of displaced intra-articular fractures of the calcaneum: a long-term review of 47 cases. *J Bone Jt Surg Br* 2010; 92(5): 693-700.
29. Zhang Q. Treatment of intra-articular calcaneal fracture by bone grafting and plastic titanium alloy plate internal fixation. *Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi* 2009; 23(6): 648-650.
30. Sanders R., Gregory P. Operative treatment of the calcaneus: present state of the art. *J Orthop Trauma* 1992; 6: 252-265.

Address for correspondence

Krzysztof Tomaszewski
Klinika Chirurgii Urazowej i Ortopedii
5. Wojskowy Szpitala Kliniczny z Polikliniką
SPZOZ
ul. Wrocławska 1-3, 30-901 Kraków, Poland
e-mail. krtomaszewski@gmail.com