Jacek LORKOWSKI[1]
Renata WILK[2,3]

The direct and indirect costs of malleolar ankle fractures surgical treatment in people of working age in Poland

Koszty bezpośrednie i pośrednie leczenia chirurgicznego złamania kostek podudzia u ludzi w wieku produkcyjnym w Polsce

[1]Department of Orthopaedics and Traumatology, Central Clinical Hospital of Ministry of Interior,
Warsaw.

[2]Department of Anatomy, Health Science Department, Medical University of Silesia

[3]Hope Medical Institute Newport News,
VA USA

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Author's correspondence address:
Jacek Lorkowski MD, PhD
Department of Orthopedics and Traumatology
Central Clinical Hospital of Ministry of Inferior
Woloska 137 St.
02-507 Warsaw
e-mail: jacek.lorkowski@gmail.com
phone: +48 606 452 887

In present time, standard treatment for malleolar fracture of the ankle is in most cases surgical treatment. Due to the method of accounting procedure imposed by the National Health Fund, these fractures are most often stabilized in the cheapest or almost cheapest way possible. The aim of the study was to analyze medical expenses spent for malleolar ankle fracture management, depending on the method of fixation and to show economic benefits of use modern methods of the ankle fusion. The study group consisted of 20 patients aged 22 to 61 (mean 38.6 years). Based on the above group of patients, standard therapeutic actions were analyzed and significant procedural costs were identified. It compares the costs of „standard" patient modeling for 5 different types of stabilization. In addition, a refund from the National Health Fund was determined for the individual therapeutic procedures. The indirect costs resulting from temporary incapacity for work due to the effects of the traumatic event are then assessed, depending on the type of treatment. The amount of hospitalization required for uncomplicated malleolar fractures of the ankle was 1 to 3. The total direct costs of whole surgical treatment in the case of malleolar fractures ranged from 2 369.94 USD to 2 796.00 USD. The indirect costs of injury, including mainly GDP loss and cost of temporary disability benefits, ranged between 20 326.93 USD and 26 898.39 USD. Indirect costs were much higher than direct costs. The difference between them was: 24 174.17 USD for a group of patients stabilized with the old Osteo system, over 21 000 USD for patients stabilized with biodegradable implants and over 24 000 USD for a group of patients in which the LCP system with a trefoil was used. After comparing the total of indirect costs (loss of GDP, cost of temporary disability benefits, costs of reimbursement of treatment by the National Health Fund) and direct cost, the treatment which gives most benefit and in result least costly treatment was using the most expensive anastomosis, i.e. the biodegradable plate. Using modern implants in the case of malleolar fractures of the ankle allows for reduction of indirect costs. In the analyzed case, the reduced indirect costs outweigh the increased direct costs. Current, existing over a 10-year reimbursement system offered by the National Health Fund in Poland, makes unprofitable use of modern implants in the

Standardowym postępowaniem w przypadku złamań kostek goleni jest w większości przypadków (poza izolowanym złamaniem kostki bocznej, bądź przyśrodkowej) leczenie operacyjne. Ze względu na sposób rozliczania procedury narzucony przez NFZ, złamania te najczęściej są stabilizowane w najtańszy, bądź prawie najtańszy, możliwy sposób. Celem pracy była analiza nakładów finansowych ponoszonych w związku z leczeniem złamania kostek goleni, zależnie od sposobu stabilizacji oraz wykazanie korzyści z zastosowania najnowszych typów zespoleń. Grupę badaną stanowiło 20 chorych, obojga płci (10 kobiet, 10 mężczyzn), w wieku od 22 do 61 lat (śr. 38,6 lat), operowanych przez jednego ortopedę w latach 2012-2015. W oparciu o powyższą grupę chorych, przeanalizowano standardowe działania terapeutyczne i wyróżniono istotne z punktu widzenia kosztów procedury. Porównano koszty leczenia „standardowego" chorego modelując je dla 5 różnych typów stabilizacji. Ponadto, określono refundację z NFZ dla poszczególnych procedur terapeutycznych. Następnie oceniono koszty pośrednie wynikające z czasowej niezdolności do pracy, w związku z następstwami przebytego urazu, zależnie od rodzaju podjętego leczenia. Ilość koniecznych hospitalizacji w przypadku niepowikłanego leczenia złamań kostek goleni wynosiła od 1 do 3. Suma kosztów bezpośrednich całości leczenia operacyjnego w przypadku złamań kostek goleni wynosiła od 2 369,94 USD do 2 796,00 USD. Koszty pośrednie urazu, w tym głównie utrata PKB i koszty świadczeń z tytułu czasowej niezdolności do pracy wynosiły odpowiednio pomiędzy 20 326,93 a 26 898,39 USD. Koszty pośrednie były znacznie wyższe od kosztów bezpośrednich. Różnica pomiędzy nimi wynosiła: 24 174,17 USD dla grupy pacjentów stabilizowanych starym systemem Osteo, ponad 21 000 USD dla pacjentów stabilizowanych implantami biodegradowalnymi i ponad 24 000 USD dla grupy pacjentów, w której zastosowano do stabilizacji system LCP z trefinką. Po porównaniu całości podstawowych kosztów pośrednich (utrata PKB, koszty czasowej niezdolności do pracy, koszty refundacji leczenia przez NFZ) i bezpośrednich, najtańsze było leczenie z zastosowaniem najdroższego zespolenia, tj. płyty biodegradowalnej. Używanie nowoczesnych implantów w przypadku złamania kostek goleni pozwala na zmniejszenie kosztów pośrednich.

case of malleolar fractures of the ankle (taking into account only direct costs). From the economic point of view, i.e. the national budget, due to the lower aggregate costs (the difference between direct and indirect costs) it is advisable to introduce modern stabilization methods (plates and biodegradable screws).

W analizowanym przypadku zmniejszone koszty pośrednie przewyższają zwiększone koszty bezpośrednie. Aktualny, istniejący od ponad 10 lat, sposób refundacji przez NFZ, czyni nieopłacalnym stosowanie nowoczesnych implantów w przypadku złamania kostek goleni (biorąc pod uwagę jedynie koszty bezpośrednie). Z punktu widzenia ekonomicznego, tj. budżetu państwa, ze względu na mniejsze sumacyjne koszty (różnica pomiędzy kosztami pośrednimi i bezpośrednimi) wskazane jest wprowadzenie najnowszych sposobów stabilizacji (płyty i śruby biodegradowalne).

Introduction

Medical expenses represent an increasing percentage of the national budged expenditure as well as the household budged of a statistical citizen. Usually, more attention is paid to the analysis of direct costs than indirect costs. This problem has been analyzed many times, although it is still not widely known [1,2]. Part of the analysis of indirect and direct costs is not likely to be performed in Poland at all, given that direct costs are a priori preventive of such discussion, where the way of medical facilities financing from the National Health Fund is a system based on HPG (Homogeneous Patient Groups) procedures [3]. An example of this is the malleolar fracture of the ankle. This is one of the most frequent injuries treated in traumatic orthopedic surgery units [4]. The standard procedure for displaced malleolar fractures of the ankle that can't be repaired conservatively, in particular with damage to the tibiofibular syndesmosis and in bi- and three- malleolar fractures is surgical treatment [5]. After the initial fracture stabilization, another procedure is required, i.e. removal of the syndesmotic screw, which is implanted in the case of damage to the tibiofibular joint, usually performed 6 weeks after first procedure. After about a year, in most cases, the rest of the anastomosis is removed. Typical surgery for malleolar fractures of the ankle involves 2 or 3 operating procedures [6]. Each of them is associated with the need to hospitalized and perform specialized procedures in the operating room, hospital ward, and then in the outpatient clinic.

One way to reduce the number of standard surgical procedures needed to perform in one patient would be to use modern bonding materials, which removal would not be necessary [7] preferably bio-absorbent materials, fully biocompatible to the human tissue [8]. In each of these options, the removal of the anastomosis (usually 1 year after first procedure) would be avoided. The use of biocompatible materials alone doesn't however solve the problem of removal of the implanted syndesmotic screw. This is a procedure necessary to perform after about 6 weeks from fracture stabilization [9]. The solution found in UK and successfully used for several decades is so-called trefoil. It ensures correct biomechanical performance of the ankle joint during healing and simultaneously stabilizes the tibiofibular syndesmosis without necessity of its removal in the future [10].

Aim of study

The aim of the study was to analyze for the first time the full financial outlays and the socio-economic benefits of the use of different techniques for the stabilization of the malleolar fractures of the ankle in the case where stabilization of the lateral and medial malleolus as well as tibiofibular syndesmosis was required. The cost analysis of 3 fracture stabilization systems was performed. There were: stabilization with the oldest and the cheapest available method (Osteo, Kirschner wires), more technologically advanced method (Locking compression plate (LCP) system with trefoil) and the most technologically advanced method (bioabsorbable plates and screws).
Both direct costs resulting from the materials used as well as indirect ones covering the overall process of patient recovery after fracture were taken into account.

The number of surgeries operations necessary to perform for each group.

Materials and methods

The study group consisted of 20 patients, both sexes (10 females, 10 males) treated by one orthopedic and trauma surgeon who underwent the malleolar fracture of the ankle and requiring lateral or medial malleolus as well as tibiofibular syndesmosis stabilization. These were employed persons aged 22 to 61 (mean 38.6 years), operated in Central Clinical Hospital of Ministry of Interior in Warsaw in the years of 2012-2015. Documentation of stationary and outpatient treatment has been analyzed since the time of injury to the complete treatment cessation. The total direct costs of treatment were calculated, taking into account both the costs of surgery as well as other procedures performed during and after hospitalization. Additionally, the time of work incapacity for the study group, directly related to the traumatic event and its consequences, was analyzed. Attention was paid to the occurrence of additional financial burdens on the part of the national budget resulting from malleolar fractures of the ankle. Data on the costs of individual procedures were obtained from one of the Polish hospital, the remaining data from the information published by the Polish Central Statistical Office. Based on the study group, approximate cost estimates of various potentially possible operative fracture treatments were compiled. It was possible to distinguish 5 groups (subgroups) according to the way of stabilization (Tab.I). A cost analysis for each of the group covering both direct and indirect costs was presented. Based on the standards applicable to the treatment of malleolar fractures of the ankle, the cost analysis takes into account the time required for subsequent surgical procedures, control and rehabilitation treatment. Total treatment time included: healing of postoperative wound, regeneration of tibiofibular syndesmosis as well as fracture union.

Grupa	Type of stabilization applied to the patient
1	Stabilization of malleolar fractures of the ankle using 4 Kirschner wires, tension band wire and syndesmotic screw with cleats.
2	Stabilization of the malleolar fracture of the ankle with an Osteo plate with 5 screws (including one syndesmotic) and the medial malleolus fracture using ankle screw with cleat and Kirschner wire (anti rotation wire).
3	Stabilization of lateral malleolus fracture using Locking Compression Plate (LCP) system with screws (including 3 cortical screws and 4 blocking) and medial malleolus fracture using cannulated screw with cleats and anti rotation wire.
4	Stabilization of lateral malleolus fracture using LCP system with screws (including 3 cortical screws and 4 locking) and medial malleolus fracture using cannulated screw with cleats and anti rotation wire. Stabilization of tibiofibular syndesmosis using so - called trefoil.
5	Stabilization of lateral malleol us fracture using biodegradable LCP system and biodegradable screws (including 3 cortical screws and 4 locking) and medial malleolus fracture using 2 cannulated screws with cleats (also biodegradable).

Table I.
Groups (subgroups) distinguished depending on the stabilization method.

In each group (1 to 5) fracture stabilization is required. During treatment in groups 1 to 3 it's necessary to remove the syndesmotic screw. However in groups 4 and 5 there is no need to do so. Later on in groups 1 and 2 there are substantial indications for removing whole anastomosis. In groups 3 and 4 whole anastomosis can be removed but it's not obligatory.
In group 5 there is no necessity of anastomosis removal. Frequency of standard outpatient controls required after surgery After surgical stabilization of the fracture, outpatient control is required in each study group (1 to 5) on the day 0, 3 times right after surgery, 14 days after surgery and 42 days after surgery. Additional outpatients control is required 3 months after fracture stabilization and again 6, 12 and 24 months. In case of necessity of syndesmotic screw removal at 6 weeks after the first treatment (in groups from 1 to 3) additional outpatient controls are required: 3 times right after surgery and 14 days after the second surgery. In case of further necessity of whole anastomosis removal (in groups 1 and 2 and conditionally in groups 3 and 4) the additional outpatient controls schedule is the same as above 3 times right after surgery and 14 days after the second surgery, supplemented with control after 42 days from the third surgery. Analyzing the number of surgical procedures and outpatient controls for individual group of patient, it can be stated: for group 1 and 2 the number of surgical procedures was three (fracture stabilization, syndesmotic screw removal, whole anastomosis removal). Number of outpatient controls was 18. For group 3 the number of surgical procedures was two (fracture stabilization, syndesmotic screw removal) or three (in addition to the need for removal of the entire anastomosis). Number of all outpatient controls was 13 or 18 depending on number of the procedure required. For group 4 the number of surgical procedures was one (fracture stabilization) or two (in addition to the need for removal of the entire anastomosis). Number of all outpatient controls was 9 or 14 depending on number of procedures. For group 5 the number of surgical procedures was one (fracture stabilization). Number of all outpatient controls was 9. Creating the study groups in order to obtain the best groups comparison, some inclusion and exclusion rules were adopted, i.e.:

- No complications in treatment (without the need for additional surgery or outpatient controls, no prolonged incapacity, etc.);
- Only the most important costs were analyzed;
- Particular attention was paid to the procedures that were different (and therefore their costs were different) in each of the analyzed groups;
- The cost of first aid at the scene of the accident, transfer of patient with fracture to the Hospital Emergency Room as well as procedures of admission to the orthopedics and traumatology ward, were excluded;
- The optimal case, in which the surgical treatment was performed approximately 24h hours after injury, was adopted.
- 3-day hospitalization for fracture stabilization, 2-day hospitalization for removal of the syndesmotic screw and also 2-day for removal of whole anastomosis were adopted.

Direct costs analysis

The following direct costs were analyzed, i.e. costs of treatment:

1) For all 5 groups the costs of surgical fracture stabilization were taken into account. They consisted of:

a. Costs of surgical anastomosis including: personnel costs of the surgical team, costs of implants, other material costs (price of materials used during the procedure, price of medicines);

b. Costs of hospitalization for fracture stabilization including: personnel costs of the medical team (doctors and nurses), costs of physiotherapeutic and ancillary services, costs of laboratory tests and radiological examinations, costs of pharmacotherapy and other material costs (dressings, etc.) as well as costs of Hospital fee;

c. Outpatient care costs include: personnel expenses (doctor, nurse, support staff), material costs (dressings, disinfectants), costs of radiological examinations;

d. Rehabilitation treatment costs including: personnel expenses (medical rehabilitation specialist, physiotherapist, support staff), material costs (dressings, kinesiology tapes, etc.)

2) For groups 1-3, the costs of additional surgical removal of syndesmotic screw as well as associated hospitalization, were included (personnel and material).
3) For groups 1-2, the cost of surgical removing of entire anastomosis was included (personnel and material) together with associated hospitalization. Because in groups 3 and 4 indications for this procedure were not so clearly defined, it was assumed that procedure was performed in 50% of patients.

Indirect costs analysis

Indirect costs were subsequently analyzed. The standard time of incapacity for this condition was calculated, depending on the type of surgical treatment used. The period of 5 months (whole orthopedic and rehabilitation treatment period) was assumed as the time of incapacity after surgery and surgical treatment. It also included a period directly related to the syndesmotic screw removal (approximately 6 weeks after first surgery). A 6-week period has been adopted as a necessary time of incapacity if the rest of the anastomosis has to be removed about one year after fracture stabilization. The incapacity period was established based on the study group. The cost analysis performed mainly includes the benefits received by patients for temporary incapacity and GDP (Gross Domestic Product) loss. More precisely the loss of Gross Domestic Income (GDI), due to temporary incapacity for work was analyzed. According to data from the Statistical Yearbook of Poland 2017, it was assumed that GDI in 2016 amounted to 544.46 billion USD [11]. Based on the same source, the number of people employed in the national economy amounted to – 16 328 thousand. Based on this data, the cost of unprocessed national income (GDP loss) was calculated, assuming incapacity at 5 or 6.5 months. All amounts has been converted into US dollars, US dollar exchange rate on the day 22nd of January 2018 according to National Bank of Poland was 3.40 PLN = 1 USD ($). The costs of temporary incapacity benefits were then analyzed. Based on data obtained from the literature the average salary in Poland in 2016 was: 1 190.36 $ per 1 month [12]. Considering this value, the benefits received by patients were calculated. The value of benefits received by patients due to temporary incapacity was assumed to be 80% of the average salary per 1 month, i.e. PLN 952.28 $ taking into account respectively 5 and 6.5 month incapacity periods. In order to thoroughly analyze the problem, the reimbursement costs of the National Health Fund for specific procedures were taken into account.

Results

Direct costs calculation

At first the total costs medical procedures and outpatient controls were calculated. Direct costs of surgical treatment of malleolar ankle fracture stabilization and hospitalization for this procedure (without implant price), calculated per working hours and number of people in team were listed below:

Personnel costs include the following:

1.Orthopaedics and traumatology specialist 1 Person (x1) - 1 hour – 24.80$; 2. Orthopaedics and traumatology resident (x1) – 1h – 11.35$; 3. Scrub nurse (x2) – 1.5h 37.94$; 4. Anesthesiology specialist (x1) – 1h – 26.47$; 5. Nurse anesthetist – (x1) - 1.5h – 15$; 6. Person cleaning the operating room (x1) – 0.5h – 1.89$;
Total cost of the medical team was 117,45$.
Material costs (without implant) were listed below:
1. Material costs (orthopedics) excluding implant – standard set – 38.24$;
2. Medicines used in the operating ward – standard set – 14.71$;
Total material costs excluding implant – 52.94$.

Costs of hospitalization except surgery:

Personnel costs:
1. Orthopaedics and traumatology specialist (x1) – time of work 0.25h – 6.20$; 2. Orthopaedics and traumatology resident (x1) – 0.25h – 2.84$; 3. Nurse (x1) – 1.5h – 13.90 USD; 4. Physiotherapist (x1) – 0.25h – 1.06$; 5. Medical assistant (x1) - 0.25h – 1.22$;
Total cost of the medical team was: 25.21$.

Material costs:
1. Medicine used in the ward before and after surgery – standard set for 1 surgery – 14.71USD;
2. Costs of laboratory tests – 1 set – 34.71$;
3. Chest X–ray (x1) – 22.06$;
4. The X–ray of operated ankle joint (before and after surgery) – 2 sets (4X--rays) – 38.24$;
5. Cost of rehabilitation equipment for 1 patient – 1 time – 21.47$;
6. Material costs of dressing changes – standard set – 3.71$;
Total material costs: 134.88$.
7. Sum-lump Hospital fee for 3 days – 441.18$.
Total direct costs of the malleolar ankle fracture stabilization amounted to : 771.66$.
Direct costs of surgical syndesmotic screw removal and hospitalization for this procedure, were listed below:
Personnel costs include the following:
1. Orthopaedics and traumatology specialist 1 person (x1) – 0.25h – 6.20$;
2. Orthopaedics and traumatology resident (x1) – 0.25h – 2.84$;
3. Scrub nurse (x2) – 0.5h – 12.65$;
4. Anesthesiology specialist (x1) – 0.25h – 6.62$;
5. Nurse anesthetist – (x1) - 0.5h – 5.00$;
6. Person cleaning the operating room (x1) – 0.25h – 0.95$;
Total cost of the medical team was 34.24$.

Material costs
1. Material costs – standard set – 38.24$;
2. Medicines used in the operating ward – standard set – 14.71$;
Total material costs – 52.94$.

Costs of hospitalization except surgery:

Personnel costs:
1. Orthopaedics and traumatology specialist (x1) – time of work 0.25h – 6.20$; 2. Orthopaedics and traumatology resident (x1) – 0.25h – 2.84$; 3. Nurse (x1) –1h – 9.27$; 4. Physiotherapist (x1) – 0.25h – 1.06$; 5. Medical assistant (x1) - 0.25h – 1.22$;
Total cost of the medical team was: 20.58$.
Material costs:
1. Medicine used in the ward before and after surgery – standard set – 14.71$;
2. Costs of laboratory tests – 1 set – 34.71$;
3. The X–ray of operated ankle joint (after surgery) – 1 set (2X-rays) – 22.06$;
4. Material costs of dressing changes – standard set – 3.71$;
Total material costs: 75.18$;
5. Sum-lump Hospital fee for 2 days – 294.12$.
Total direct costs of the syndesmotic screw removal amounted to: 477.06$.

Direct costs of surgical removing of entire anastomosis as well as hospitalization for this procedure, were listed below:

Personnel costs include the following:
1. Orthopaedics and traumatology specialist 1 person (x1) – 0.5h – 12.39$; 2. Orthopaedics and traumatology resident (x1) – 0.5h – 5.67$;
3. Scrub nurse (x2) – 1h – 25.29$;
4. Anesthesiology specialist (x1) – 0.5h – 13.24$;
5. Nurse anesthetist – (x1) -1h – 10$;
6. Person cleaning the operating room (x1) – 0.25h – 0.95$;
Total cost of the medical team was 67.54$.

Material costs
1. Material costs – standard set – 38.24$;
2. Medicines used in the operating ward – standard set – 14.71$;
Total material costs – 52.94$.

Costs of hospitalization except surgery:

Personnel costs:
1. Orthopaedics and traumatology specialist (x1) – time of work 0.25h – 6.20$;
2. Orthopaedics and traumatology resident (x1) – 0.25h – 2.84$;
3. Nurse (x1) –1h – 9.27$;
4. Physiotherapist (x1) – 0,25h – 1.06$;
5. Medical assistant (x1) - 0,25h – 1.22$;
Total cost of the medical team was: 20.58$.

Material costs:
1. Medicine used in the ward before and after surgery – standard set – 14.71$;
2. Costs of laboratory tests – 1 set – 34.71$;
3. The X–ray of operated ankle joint (after surgery) – 1 set (2X-rays) – 22.06$;
4. Material costs of dressing changes – standard set – 3.71$ PLN;
Total material costs: 75.18$.
7. Sum-lump Hospital fee for 2 days – 294.12$.
Total direct costs of entire anastomosis removal amounted to: 510.36$

Costs of outpatient control with X-ray and dressing change were listed below:

Personnel costs:
1. Orthopaedics and traumatology specialist (x1) – time of work 0.25h – 6.20$;
2. Nurse (x1) – 0.25h – 2.32$;
3. Cleaning person (x1) – 0.25h– 0.96$;
Total cost of the medical team was: 9.48$

Material costs
1. The X–ray of operated ankle joint (after surgery) – 1 set (2X-rays) – 22.06$;
2. Material costs of dressing changes – standard set for 1 control – 3.71$;
Total material costs: 25.76$.
2. Sum-lump Hospital fee – 1 time 2.94$.
Total cost of 1 outpatient control (with X ray and dressing change) amounted to: 38.19$.
Costs of outpatient control with X-ray without dressing change were listed below:

Personnel costs:
1. Orthopaedics and traumatology specialist (x1) – time of work 0.25h – 6.20$;
2. Nurse (x1) – 0.25h – 2.32$;
3. Cleaning person (x1) – 0.25h – 0.96$;
Total cost of the medical team was: 9.48$.

Material costs
1.The X–ray of operated ankle joint (after surgery) – 1 set (2X-rays) – 22.06$.
2. Sum-lump Hospital fee – 1 time 2.94$.
Total cost of 1 outpatient control (with X ray without dressing change) amounted to: 34.48$.

Costs of outpatient control with dressing change and removal of the stitches procedure were listed below:

Personnel costs:
1. Orthopaedics and traumatology specialist (x1) – time of work 0.25h – 6.20$;
2. Nurse (x1) – 0.25h – 2.32$;
3. Cleaning person (x1) – 0.25h – 0.96$;
Total cost of the medical team was: 9.48$.

Material costs
1. Material costs of dressing changes – standard set for 1 control – 3.71$;
2. Sum-lump Hospital fee – 1 time 2.94$;
Total cost of 1 outpatient control with dressing change and removal of the stitches procedure amounted to: 16.13$.

As the next step the costs of rehabilitation treatment were calculated. After malleolar ankle fracture stabilization procedure, 2 cycles of rehabilitation are recommended (according to the National Health Fund instruction). In case of necessity to perform another surgical procedure (removal of entire anastomosis) another 2 cycles should be provided.
Costs of 2-week rehabilitation cycle
Personnel costs
1. Medical rehabilitation specialist (x1) – 0.25h – 6.20$;
2. Physiotherapist (x1) –10h- 42.56$;

3. Cleaning person (x1) – 0,5h- 1.87$;

Total personnel costs: 50.63$.

Material costs

1. Material costs of rehabilitation treatment after hospitalization (dressing materials, medicine for physiotherapy procedures, kinesiology tapes) – 10 days of treatment – 52.94$.
2. Sum-lump Hospital fee – 10 times – 29.41$

Total cost of 2 week rehabilitation cycle 132.98$ - 2 cycles – 265.96$

Summary of the total direct treat ment costs in the analyzed study gro ups

Costs in group 3 and 4 were calculated depending on the necessity of syndesmotic screw removing or not.

Assuming that, according to the clinical observations 50% of patients need additional surgical procedures, mean values (arithmetic mean of two possible values in a given group) of the total direct cost in group 3 and 4 were calculated.

The total mean values of direct costs of the malleolar ankle fracture treatment ranged from 2 607.07$ in group 3 to 2 796.00$ in group 5, implant cost for 1st procedure ranged 10.59$ in group 1 to 1502.94$ in group 5.

Indirect costs calculation including the reimbursement by the NHF

Gross domestic product (GDP) loss and cost of temporary inability to work.

The gross domestic product per one employed in the economy per one month in 2016 amounted to 2778.78$. The cost of temporary incapacity to work was calculated based on the average monthly earnings achieved in the economy in 2016, amounting to 1190.36$. Benefits resulting from inability to work were calculated as 80% of income so 952.28$. In the examined groups from 1 to 5, the loss of gross domestic product (GDP) and the costs of temporary incapacity to work were calculated for 5 or 6.5 months depending on the need to remove the entire anastomosis. In group 1 and 2, the anastomosis is always removed, in groups 3 and 4 it is necessary in 50% of patients. In table 3 the mean values of cost are given.

Cost reimbursement in accordance to the National Health Fund valuation.

The refund of procedures according to NHF points differs depending on whether it concerns hospitalization, outpatient or orthopedic control as well as physiotherapeutic procedures.

1. Ankle fracture stabilization and hospitalization for this procedure (NHF – 89) – reimbursement 1 361.18$;
2. Surgical syndesmotic screw removal and 2 days hospitalization (NHF points – 23) – reimbursement 351.76$;
3. Surgical removing of entire anastomosis and 2 days hospitalization (NHF points – 23) – reimbursement 351.76$;
4. Outpatient controls (NHF points from 3.5 to 7) reimbursement from 9.78$ to 19.56$ per visit.
5. Rehabilitation treatment (1 day) with regard to kinesi and physio therapy (3 physiotherapeutic treatments and kinesitherapy (NHF points - 48) – reimbursement 16.38$.

It has been found that the most expensive type of stabilization i.e. the biodegradable plate, is the most effective taking into account socio- economic conditions. In this case the total cost was of treatment amounted to 23 122.93 USD and was lower by 5.5 thousand dollars for treatment with use of the oldest system and 3.5 thousand USD using more advanced methods.

Number of Group	Cost of surgical procedures and hospitalization, mean values for Gr. 3 and 4 (SD)	Cost of outpatient visits, mean values for Gr. 3 and 4 (SD)	Rehabilitation treatment, mean values for Gr. 3 and 4 (SD)	Total direct cost without implant, mean values for Gr. 3 and 4 (SD)	Cost of implant	Total direct cost, mean values for Gr. 3 and 4 (SD)
1	1 759.09$	422.63$	531.92$	2 713.63$	10.59$	2 724.22$
2	1 759.09$	422.63$	531.92$	2 713.63$	41.18$	2 754.81$
3	1 503.91$ (360.88$)	371.28$ (72.61$)	398.94$ (188.06$)	2 274.13$ (621.55$)	332.94$	2 607.07$ (621.55$)
4	1026.84$ (360.88$)	287.69$ (45.61$)	398.94$ (188.06$)	1 713.47$ (594.55$)	656.47$	2 369.94$ (594.55$)
5	771.66$	255.43$	265.96$	1 293.06$	1 502.94$	2 796,00$

Table II.
Total direct cost of the treatment for each analyzed group, mean values in USD.

Discussion

Orthopedics originates from ancient Egypt, then in the modern era from Ambrose Pare (1510-1590) and Percivall Pott (1714-1788). The actual cost of treatment wasn't calculated at that time. The main medical expenses, described in the literature, were the patient's gratitude to the doctor. Accurate calculation of medical costs began in the 1970s [13]. The first thorough analyzes were carried out on costs generated by traumatic patients. The benefits and economic losses of various therapeutic actions have been analyzed. These studies were conducted mainly in the United States, but also in other countries, i.a. in Western Europe and in Poland [14]. https://www.ncbi.nlm.nih.gov/pubmed/?term=Rezaei%20S%5BAuthor%5D&cauthor=true&cauthor_uid=24045158.

The inspiration for these activities was the economic analysis of the effects of the Vietnam War and the „largest American war of the twentieth century" (traffic accidents) [13,14]. All studies indicated that, in the treatment of traumatic patients, direct costs are lower than the indirect costs incurred, the most important of which are the costs of the loss of Gross National Product [1]. The analysis included mainly patients with multi-organ injuries where the use of inappropriate or delayed treatment resulted in the so-called „falling out" from the labor market. These patients not only did not increase the national income, but with paid pensions, they generated new expenses [1]. It must be kept in mind that for patients with multi-organ injury, enormous direct costs incurred for the treatment of each individual patient have to be taken into consideration [1,3]. Another situation is to treat the patient with the malleolar ankle fracture, which is one of the most common injuries. It is stated that 11.13 per 1000 patients per year treated at orthopedic and traumatology wards show ankle fracture [15]. The costs of treating these patients are not even close to that which generates multi-organ injuries, revision endoprosthesis or endoprosthesis after malignant tumor resection.

In the case of malleolar ankle fractures, however, the problem lies in the prevalence of injury [5]. Taking into account the young age of patients, each day of additional treatment and incapacity for work generates additional costs, noticeable in the national budget. In the study group, it was found that using modern methods including biodegradable implants can reduce the statistical costs of fractures of the ankle bone by 3 or even 6 thousand USD depending on the selected method of treatment. It should be noted that the cost of treatment was lower, with the use of modern implantation, although at first glance in absolute terms they were huge.

This work is a contribution to the description of the method of reimbursement of orthopedic treatment by NHF in Poland, which leads to its underestimation in the case of trauma and orthopedic patients. The indirect costs presented in this work didn't, of course, exhaust all the possibilities that are used in such calculations, but for the purposes of this study they seemed to be sufficient.

The early start of rehabilitation treatment allowed for the optimal course of fracture healing and the return of the

biomechanical function of the limb. In addition, it reduced the likelihood of dysfunction occurrence from other parts of the locomotor system [16,17]. It must be remembered that the overall biomechanical performance of a motor organ requires the proper function of each of its components. The lack of correct functioning of the ankle joint over longer period of time will undoubtedly result in the need for more complex and therefore expensive treatment of adjacent joints as well as a spine [18,19]. This has been confirmed i.e. by the studies conducted during the Decade of Bones and Ponds research project [20]. The problem of treating injuries and their consequences should therefore be approached as a socio-economic process that needs to be managed effectively [21,22]. Please note that only the simple course of treatment was included in the analysis presented. No complications were considered. Complications can be caused by the timing of fixation and also by the time spent in the hospital [15,23] which is not the case here because all patients were operated almost in the same period after fracture. Truism is however the statement that every subsequent operation increases the probability of infection. Treatment of this type of complication definitely increases global direct and indirect costs. At least 2% of patients are affected by the infection of the operated site, as stated in the literature [24,25]. As given by Kheir et al. [15] the costs of early ORIF (Open Reduction Internal Fixation) treatment, which would be comparable with our data, between patients without complications and with any complications range from 3 108£ (4 323$) to 93 240£ (129 713$) in UK taking into consideration only direct costs of treatment. The costs including readmissions of different reasons (i.e. removal of syndesmosis screw) after first treatment showed higher costs of treatment in the range of 4 730.28£ (6 580$) in UK [26]. In US the same costs were given as over 60 000$ median overall costs of treatment [27]. In Bonafede [28] analysis of management of lower extremity fractures in US taking into account direct and indirect costs of treatment for tibial fracture the total direct costs amounted to 10 070$ indirect cost including short term disability amounted 3 596$ and absenteeism costs 1 570$ what gives altogether 15 236$ however direct cost were calculated only for fractures not requiring external fixation. If internal fixation was necessary the costs ranged to 5.7 higher because of their more severity and because of this more extensive healthcare. According to different costs of healthcare in different countries it's really hard to compare them the fact is that economic benefits increase with the reduction of number of further surgical operations and possible complications. Similarly, the problem of destabilization of anastomosis was not taken into account however using blocking screws, the probability of the anastomosis destabilization is low [29]. A separate problem, resulting from the previous ones, is complications leading to the need for arthrodesis or ankle joint endoprosthesis [30]. All those procedures are costly and definitely increase the costs of full treatment. When analyzing the above problem from an economic point of view it is important to pay attention to what is most essential in medicine. The method of treatment choose by doctor should improves the quality of life of the patient, reducing the number of surgical procedures and the duration of treatment [6,7]. This goal is possible to achieve using modern methods of stabilization. It should be taken into account that illness, and therefore temporary incapacity for work causes periodic social exclusion and may raise the probability of mental disorders, with less or greater severity. This results in a further increase in indirect and direct costs, in this case hidden. They are difficult to recognize because they are not combined with direct cause, in here an ankle injury [31,32]. Data provided from the study of the outcomes of lower extremity fractures showed that 28% of patients didn't return to work in 12 month period after fracture. Other had different disabilities of various severity 17% mild, 12% moderate and 7% severe [33]. On the basis of the analysis, it can be stated the use of modern implants in the case of malleolar ankle fracture treatment allowed reducing both direct and indirect costs by the reduction of complications and other conditions connected to them. In the analyzed case, increased direct costs were offset by reduced indirect costs.
Analysis made by Cots [34] showed that revision surgeries have definitely higher costs and length of stay compared with the primary. Especially in Poland these cost was higher in comparison to other European countries. The funding system existing for more than 10 years in Poland and the way of refunding from the National Health Fund makes unprofitable, from the medical unit's point of

Number of Group	GDP loss, mean values Gr. 3 and 4 (SD)	Cost of temporary inability to work, mean values Gr. 3 and 4 (SD)	Reimbursement from NHF, mean values	Total indirect cost mean values	Total cost of treatment (direct + indirect)	Differences between direct and indirect cost
1	18 062.04$	6 189.85$	2 646.50$	26 898.39$	29 622.61$	24 174.17$
2	18 062.04$	6 189.85$	2 646.50$	26 898.39$	29 653.20$	24 143.28$
3	15 977.96$ (2 947.34$)	5 475.64$ (1 010.05$)	2 354.51$ (164.20$)	23 808.10$ (4 121.59$)	26 415.17$ (4 743.14$)	21 201.03$ (3 830.71$)
4	15 977.96$ (2 947.34$)	5 475.64$ (1 010.05$)	1 963.63$ (164.20$)	23 417.22$ (4 121.59$)	25 787.16$ (4 716.14$)	21 047.28$ (3 527.04$)
5	13 893.88$	4 761.42$	1 671.63$	20 326.93$	23 122.93$	17 530.93$

Table III.
Total indirect cost of the treatment for each analyzed group, mean values.

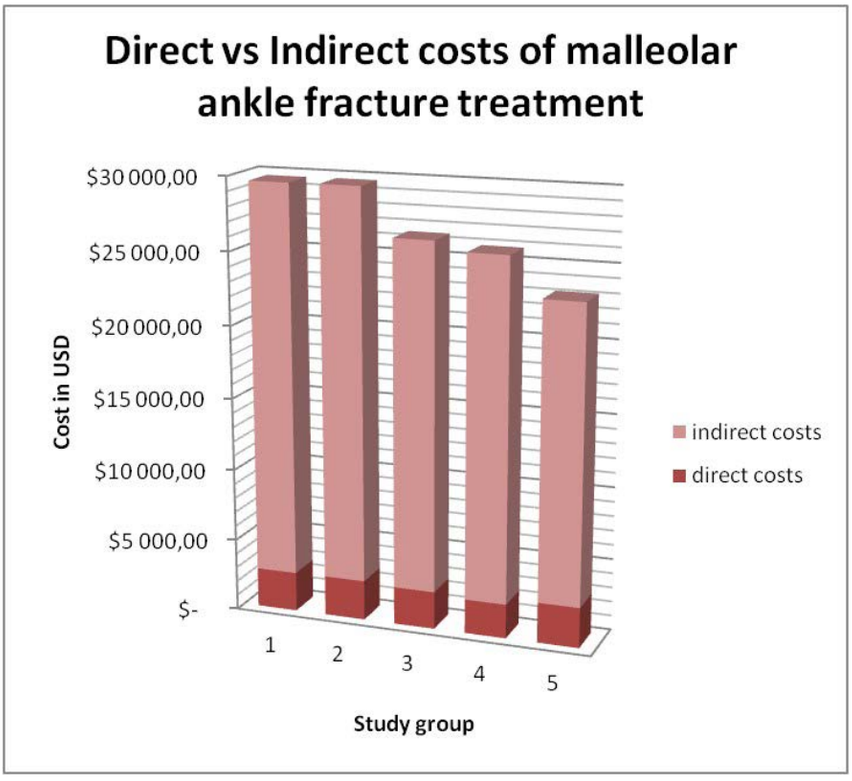

Fig. 1.
Direct vs indirect costs of malleolar ankle fracture treatment in individual study group (in USD).

view, the use of modern implants in the case of fractures of the ankle (the lowest subsidized, generating the highest direct costs). From the economic point of view (i.e. the State Budget), because of the lower overall costs (the difference between direct and indirect costs), the introduction of the most advanced stabilization methods (plates and biodegradable screws) seems to be the best choice, in this specific case.

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