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Wydawca: Exemplum

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## PRACA ORYGINALNA

Ortopedia dziecięca

# Peripheral nerve injuries after pediatric supracondylar humerus fracture

## Zaburzenia funkcji nerwów w złamaniach nadkłykciowych kości ramiennej u dzieci

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### Abstract

**Introduction:** Peripheral nerve injuries after pediatric supracondylar humerus fracture are one of the most serious complications after vascular injuries and occur in 10-20 % of cases.

**Aim of the study:** The aim of the study was assessment of peripheral nerve function in pediatric patients with supracondylar humerus fracture with nerve dysfunction and analysis of the available data to develop guidelines for surgical revision of injured nerves.

**Material and methods:** Between 2014 and 2016 in the Department of Orthopaedics and Traumatology Medical University of Gdańsk 218 children were treated because of supracondylar humerus fracture. 29 subjects (13%) sustained peripheral nerve injury. 15 subjects were qualified for further investigations. Peripheral nerve function was evaluated during neurological examinations consisting of sensory and motor function tests.

**Conclusions:** Proper qualification of the patients for surgical exploration of injured nerves after pediatric supracondylar humerus fracture results in proper restoration of nerve function of affected extremity.

**Key words:** pediatric supracondylar humerus fracture, peripheral nerve injuries

### Streszczenie

**Wstęp:** Zaburzenia funkcji nerwów w przebiegu złamania nadkłykciowego kości ramiennej u dzieci zaliczane są do najcięższych powikłań tego typu urazu i występują od 10 do 20% przypadków.

**Cel pracy:** Celem pracy była ocena funkcji nerwów u pacjentów ze stwierdzonym ich uszkodzeniem, w przebiegu złamania nadkłykciowego kości ramiennej oraz dostępny materiał celem opracowania wskazań do wykonania zabiegu rewizji uszkodzonych nerwów.

**Materiał i metody:** W latach 2014-2016 w Katedrze i Klinice Ortopedii i Traumatologii Narządu Ruchu Gdańskiego Uniwersytetu Medycznego leczono 218 dzieci z powodu złamania nadkłykciowego kości ramiennej. U 29 pacjentów (13% badanej grupy chorych), rozpoznano zaburzenia funkcji nerwów w przebiegu złamania. Badaniu kontrolnemu poddano grupę 15 chorych. Ocena powrotu funkcji nerwów polegała na badaniu neurologicznym chorych, na które składała się ocena funkcji sensorycznej (czuciowej) i motorycznej (ruchowej).

**Wnioski:** Właściwa kwalifikacja chorych do operacyjnej rewizji porażonych nerwów w przebiegu złamania nadkłykciowego kości ramiennej pozwala uzyskać prawidłowy powrót funkcji nerwów kończyny górnej u leczonych dzieci.

**Słowa kluczowe:** złamanie nadkłykciowe kości ramiennej u dzieci, porażenia nerwów, powikłania

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## Introduction

Pediatric supracondylar humerus fractures are one of the most common elbow fractures in children and represent 55-80% of fractures of the humerus. Closed reduction and external fixation with K-wires is the method of choice for treatment in this type of injuries. One of the most serious complications of this fracture includes nerve dysfunction, which occurs in 10-20% of patients with displaced fracture. Anterior interosseous nerve, a branch of medial nerve, is involved most often. Postero-medial displacement of fracture may result in radial nerve injury. Ulnar nerve injuries are less frequent, but the nerve is at risk during medial column stabilization with K-wire [1]. There are no clear algorithms for revision of injured nerves. The decision for exploration is most often based on neurological examination and lack of progression of nerve function. The ultrasound examination, which can accurately determine the location and type of nerve damage, is helpful in decision-making. Proper diagnosis of concomitant nerve injury is important for further correct function of affected extremity. On the other hand, proper qualification for surgical treatment prevents from long-term disturbances in nerves function.

## Aim of the work

1. Assessment of nerve function return in subjects with supracondylar humerus fracture.
2. Analysis of the available data, to create algorithm for surgical exploration of damaged nerves.

## Material and methods

Between 2014-2016, 218 children with supracondylar humerus fracture were operated in the Department of Orthopedics and Traumatology Medical University of Gdansk. 29 patients (13%) had concomitant nerve injury: medial nerve palsy 48.3%, radial nerve palsy 27.6% and ulnar nerve palsy 20.7%. In one case (3.4%) both radial and median nerves were affected. 31% of the patients with nerve damage were diagnosed as iatrogenic injuries. In 65.5% of patients, a primary or secondary revision of an affected nerve was performed. In other cases non-operative treatment was performed. Qualification for surgical treatment was clinical status, lack of neurological improvement on follow-up, and positive ultrasound examination performed by experienced person to determine the type and level of nerve damage.

15 subjects were included into a follow-up, while the remaining 14 did not respond to the invitation list. Clinical data showed that 7 patients from the study group suffered from the median nerve palsy, 3 from ulnar nerve palsy and

5 had disturbances in radial nerve function. The average age of the patients from study group, at the time of injury, was 6 years 7 months (3 years 1 month to 11 years 4 months). 9 patients underwent primary or secondary revision of the affected nerve, while 6 patients were treated non-operatively.

The list of patients including sex, type of nerve injury, age at the day of injury, and method of treatment are presented in Table 1.

Table 1. Study group

No.	Sex	Age at the day of injury (years)	Affected nerve	Surgical Revision
1	M	4,1	median	no
2	M	10,4	median	yes
3	F	4,7	median	yes
4	M	4,9	median	yes
5	M	5,6	median	no
6	M	7,9	median	yes
7	M	6	median	yes
8	M	5	ulnar	yes
9	F	8,9	ulnar	yes
10	M	8,1	ulnar	no
11	F	3,1	radial	yes
12	M	10,1	radial	yes
13	M	6,3	radial	no
14	F	11,4	radial	no
15	F	4,1	radial	no

Evaluation of nerve function recovery was based on the neurological examination including sensory and motor domain. The sensory function examination consisted of Semmes-Weinstein monofilaments test and McKinnon-Dellon two-point discrimination test (TPDT). The examination was standardized using contralateral hand results. The motoric domain was evaluated according to the scale of muscle function by Medical Research Council. Additionally, the global grip strength of both hands was measured by the use of Jamar dynamometer.

## Results

The follow-up for nerve injuries after pediatric supracondylar fracture was from 6 to 36 months (average 22,33 months) a side of type of treatment.

The study results showed a complete recovery of motor nerve function in 100% of cases. The Jamar dynamometer test did not show any significant differences in muscle strength of the comparable upper limbs. In the evaluation of sensory function 11 subjects had no differences compared to the non-affected extremity. In 3 cases the deviation from the healthy side was at the level of one monofilament size or by 1 mm in



the TPDT. Only one patient had significantly worse sensory nerve function. In this case, the median nerve was pulled in to the callus at the level of fracture gap. After osteotomy and neurolysis, the nerve was found to be narrowed to about 2 mm diameter at 2 cm length (nerve thickness above and below the narrowing was 5 mm). According to indications this segment was excised and neurorrhaphy was performed.

Comparing the nerve function recovery in two groups of patients treated conservatively and surgically, there were no significant differences between them.

The data from the surgical protocols were analyzed, including the in vivo appearance of the nerve during surgery. Anatomy of the nerve was then compared with description of the ultrasound examination (table 3).

Table 2. Results from examination.

No	Nerve	Revisi on surgery	Period from injury to examination (months)	Motor function loss according to Medical Research Council	Semmes-Weinstein monofilament test score affected side/contralateral side	Two point discrimination test results Affected side/contralateral side
1	median	no	27	no	D 2.83/D 2.83	3mm/3mm
2	median	yes	29	no	D 2.83/D 2.83	3mm/3mm
3	median	yes	16	no	F 3.61/D 2.83	11mm/3mm
4	median	yes	6	no	D 2.83/D 2.83	2mm/2mm
5	median	no	21	no	D 2.83/D 2.83	2mm/2mm
6	median	yes	17	no	D 2.83/D 2.83	3mm/3mm
7	median	yes	24	no	F 3.61/D 2.83	4mm/3mm
8	ulnar	yes	31	no	J 4.31/J 4.31	3mm/3mm
9	ulnar	yes	36	no	D 2.83/D 2.83	2mm/2mm
10	ulnar	no	14	no	F 3.61/D 2.83	5mm/5mm
11	radial	yes	33	no	J 4.31/F 3.61	not tested
12	radial	yes	20	no	F 3.61/F 3.61	not tested
13	radial	no	30	no	F 3.61/F 3.61	not tested
14	radial	no	21	no	F 3.61/F 3.61	not tested
15	radial	no	10	no	F 3.61/F 3.61	not tested

Table 3. Comparison of the in vivo nerve anatomy and ultrasound examination.

No	In vivo nerve anatomy	Ultrasound nerve description
1	No surgery performed	The nerve in about 13mm long with a blotched, fascicle picture surrounded by a connective tissue scar. Continuity of the nerves preserved.
2	The appearance of the nerve unchanged. Operated on the day of the injury.	Not performed
3	The median nerve is pulled into the f distal humerus bone, surrounded by a callus. After releasing, at the length of about 2 cm, the diameter of about 2 mm. The nerve was transected and the primary suture was performed.	The median nerve at the level of fracture gap is poorly visible, partially lost in edema, its continuity seems to be preserved.
4	Median nerve showing features of severe compression and bending. Upon release a spectacular improvement in the thickness of the nerve.	At the length of 3 mm nerve with a thinner diameter.. Continuity of the nerve preserved, at the level of narrowing the nerve folded, peak of the bend directed to the humerus.
5	No surgery performed	Median nerve with preserved continuity and edema.
6	Median nerve slightly narrowed	Not performed
7	Median nerve unchanged	Not performed
8	The ulnar nerve without significant contraction, the nerve scarification were found distally to the ulnar groove	Lack of documentation
9	Reconfiguration of bone fixation	Lack of documentation
10	No surgery performed	Not performed
11	Median nerve pulled into the scar, ingrown to the bone. After release in good	The median nerve is lost in the connective tissue scar
12	Radial nerve is pulled into the healing bone at the level of fracture gap. After releasing continuity preserved, nerve narrowed.	Not performed
13	No surgery performed	Continuity of the radial nerve preserved, no changes in ultrasound view. Nerve surrounded by a hematoma.
14	No surgery performed	Not performed
15	No surgery performed	Not performed

## Discussion

Peripheral nerve injuries are one of the most serious complications after pediatric supracondylar humerus fracture. The nerve may be damaged by a displaced, sharp segment of the proximal humerus or iatrogenic during closed reduction of displaced bone fragments and percutaneous stabilization with K-wires. According to frequency anterior interosseous nerve is damaged most often, then radial and ulnar nerves. In the study group 20,7% of nerve dysfunction referred to ulnar nerve. This may be the result of surgical technique with the use of two crossed K-wires to stabilize the fracture.

According to other authors number of ulnar nerve injuries decreases when the K-wires are introduced only from the lateral side of elbow or if a skin stab incision is made before introducing the medial K-Wire [2, 3].

Up to date there are no clear guidelines for the necessity and timing for surgical revision of nerve injury. Culp et al. suggest a revision after 6 months in case of no signs of recovery. Brown and Zinar, analyzed 162 cases of supracondylar humerus fractures treated with crossed K-wire fixation. They found 4 cases of iatrogenic ulnar nerve injury and recommended surgical revision [5].

Other authors report that 86-100% of nerve injuries associated with supracondylar humerus fractures are neuropraxia and spontaneously resolves up to 6 months from injury (average 2 - 3 months). Jobst et al. analyzed 304 patients, and found 20 patients with documented neuropraxia, that spontaneously recovered within 6 months. Similar conclusion has been made by Khademolhosseini et al [6,7].

Ramachandran et al., based on analysis of their material, recommend revision of damaged nerve in cases where: nerve paresis occurred during open or closed reduction and fracture stabilization, especially if the reposition was incomplete or if the nerve was not fully inspected during surgery; occurrence of neuropathic pain; total nerve damage with sensory paresis; gradual worsening of neurological status between 8-12 hours after injury and in the cases of accompanying blood supply disorders [8].

The analysis of our own material revealed the presence of nerves damage due to their compression by connective tissue scars forming, and in one case nerve entrapment in callus at the level of fracture gap. In these particular situations forsake of revision surgery may delay the proper return of the nerve function. In addition, the analysis of available ultrasound documentation confirms the efficacy of this method as an additional test, helpful in assessing the continuity of the nerve, its possible compression or damage by k-wires.

## Conclusions

The correct qualification of patients for surgical revision of affected nerves in the course of supracondylar humerus fracture allows for proper return of nerve pediatric patient.

An ultrasound examination performed by an experienced physician is a helpful test in decision making whether to perform a revision surgery of the affected nerve.

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## PRACA ORYGINALNA

Ortopedia dziecięca

# Ulnar nerve stability evaluation of 4 children with iatrogenic ulnar nerve palsy after closed reduction and percutaneous pinning of supracondylar humeral fracture

## Ocena stabilności nerwu łokciowego u czwórki dzieci z uszkodzeniem nerwu łokciowego po przezskórnej stabilizacji złamania nadkłykciowego kości ramiennej

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### Abstract

Supracondylar fractures of children are still big clinical challenge. Although most of them are treated conservatively, displaced ones need to be reduced and fixed in operative room, mostly by crossed percutaneous pinning. This case report 4 patients with iatrogenic ulnar nerve palsy after closed reduction and percutaneous pinning. Aim of this study is to evaluate if ulnar nerve is stable in groove of healthy limb and to estimate if ulnar nerve instability can be one of risk factor of nerve injury. As discussion I try to find studies that include an idea how to preserve ulnar nerve injury while introducing Kirschner wire from medial epicondyle.

**Key words:** supracondylar fracture, ulnar nerve palsy, percutaneous pinning

### Streszczenie

Złamania nadkłykciowe u dzieci są dużym wyzwaniem klinicznym. Złamania nieprzemieszczone leczone są zachowawczo w szynie gipsowej ramiennej. Złamania z przemieszczeniem odłamów wymagają zamkniętej repozycji i fiksacji najczęściej przy pomocy dwóch skrzyżowanych drutów Kirschnera. Uszkodzenia nerwu łokciowego przy przezskórnym wprowadzaniu drutów Kirschnera są rzadkie. Praca ta jest opisem 4 przypadków dzieci ze złamaniem nadkłykciowym leczonych przezskórną stabilizacją z iatrogennym uszkodzeniem nerwu łokciowego. Celem tej pracy jest ocena kliniczna i badanie obrazowe uszkodzonego nerwu, zbadanie stabilności nerwu łokciowego po stronie zdrowej i ocena czy niestabilność nerwu łokciowego w rowku mogła mieć wpływ na jego uszkodzenie przy przezskórnym wprowadzaniu drutów Kirschnera. W dyskusji przykłady z literatury na uniknięcie uszkodzenia nerwu łokciowego przy przezskórnej stabilizacji drutami Kirschnera.

**Słowa kluczowe:** złamania nadkłykciowe, porażenie nerwu łokciowego, przezskórna stabilizacja

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## Introduction

Supracondylar fractures are the most frequent elbow fractures among children. Undisplaced fractures are stabilized with elbow cast. The displaced ones are mostly treated with closed reduction and crossed pins percutaneous fixation. Neurovascular complications are reported in 5-19% displaced fractures. The aim of this study is to evaluate ulnar nerve function after iatrogenic palsy and to establish if ulnar nerve instability can be one of the risk factors when closed reduction and percutaneous pinning is performed.

## Method

This case report included children with supracondylar humeral fracture with ulnar nerve palsy hospitalized between 2012-2016 in Children Department of Orthopedic Clinic in Gdańsk. We analysed 4 of 5 patients with iatrogenic ulnar nerve palsy. This examination consisted of three parts: theoretical, clinical examination and USG examination. In first part modified QuickDash questionnaire and VAS pain scale were performed. In second part we tested an elbow range of motion, Froment's test, sensation resolution with Dellon discriminator and Semmens-Weinstein monofilament test as well. USG examination consisted of static part with evaluation of the ulnar nerve structure, thickness and dynamic part in which the position of ulnar nerve was visualized according to the flexed elbow.

## Results

QuickDash questionnaire resulted with 0-11,4 points, all patients showed 0 on VAS scale. Only one patient had limited range of motion because of varus elbow deformity: range of motion was 0-90° and - 5° of supination. The Froment test was in all cases negative. Sensation resolution ranged from 2-5mm and was symmetrical in both limbs. Monofilament sensation test indicated results 2.83-4.31 symmetrical for both limbs and in one case asymmetrical with the result 3,61 for operated side and 2,83 for healthy one.

In USG ulnar nerve structure loss was seen only in one patient. In two cases we observed enlarged diameter from 4 mm to 7-9 mm in side of injury. In dynamic nerve examination in 3 of 4 patients ulnar nerve moved into epicondyle apex and flattened, in one case it was stable in groove. In one patient with unstable nerve while bending elbow to about 90° nerve luxated over epicondyle apex.

## Conclusions

In all analysed cases good ulnar nerve function recovery was observed despite the palsy after operative treatment. In 2 cases USG imaging showed thickening of the nerve in side of injury that could be the neuroma in nerve continuity with no clinical effect. In 3 of 4 cases in dynamic USG while bending the elbow subluxation over epicondyle apex and fluttering of the nerve was observed. This fact could be one of the major risk factor in percutaneous pinning assuming symmetrical nerve instability.

## Discussion

The era of percutaneous pinning supracondylar humeral fractures started in 1948 and it was published by A. Swenson who described this technique in adults. Casiano in 1961 reported this method in children, since then multiple reports have been carried out and this particular method could have spread out.

Despite the good results, this fracture may cause some serious consequences including limited range of motion, post traumatic pain, disturbed axle of limb as a result of growth cartilage damage (1). Brown and Zindar, (2) among 162 cases of supracondylar fracture in children describe 6 ulnar nerve damage of which 4 were iatrogenic after percutaneous Kirschner wire pinning. Function of these injured nerves recovered spontaneously during 2-6 months. Authors suggest this period as optimal before revision of the nerve. According to avoid nerve damage Michael and Stanislas (3) recommend using nerve stimulator to monitor nerve function while inserting medial pin.

Another idea of preserving the ulnar nerve is introducing two Kirschner wires from lateral side. This solution is biomechanically less stable and results in more complications. Kallio and associates (4) described this solution but they achieved good results only among 68% patients. Authors claim that pins must diverge and pass the fracture well apart from each other and penetrate medial cortex. Green and associates (5) in retrospective study from 2005 on 71 children with Gartland II or III supracondylar fracture performed introducing medial pin in „mini-open” technique. They exposed medial epicondyle by 1cm incision, introduced medial Kirschner wire while bending elbow to about 50-70°. By using this technique no ulnar nerve was injured and only one case of ulnar nerve sensory neuropraxia was reported. Similar optimistic results are shown by Barlas and associates (6) in their report of crossed pinning supracondylar children fractures with medial 3cm incision. In 43 patients during the 48 months of follow up no ulnar nerve injury was observed. Interesting but demanding idea is intraoperatively USG imaging to establish the ulnar nerve position while



medial pinning. Francisco Soldado (7) describes 15 children with intraoperatively USG controlled medial pinning. None ulnar nerve injury was observed.

## Summary

In examined patients unstable ulnar nerve could have been one of the main factors leading to postoperative injury. Bending elbow to 90° helps to achieve an optimal fracture reduction but subluxates nerve to epicondyle apex at the same time. Performing USG examination of healthy elbow to establish ulnar nerve stability before operation can be helpful when choosing closed pinning or „mini open” technique.

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Special thanks to Ludomira Rzepecka-Wejs, PhD, for sharing experience and her contribution to this study.

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## PRACA ORYGINALNA

Ortopedia dziecięca

# Radiologic decision – making in preoperative planning of the treatment of Adolescent Idiopathic Scoliosis in the Department of Orthopaedics of the Medical University of Gdansk

## Radiologiczne planowanie przedoperacyjne w leczeniu skoliozy idiopatycznej dorastających w Klinice Ortopedii i Traumatologii Narządu Ruchu Gdańskiego Uniwersytetu Medycznego

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### Abstract

The major surgical goals in the treatment of adolescent idiopathic scoliosis (AIS) include safely obtaining correction of all aspects of the deformity and providing good coronal and sagittal balance with as few fused motion segments as possible. Patient radiographic evaluation is an essential point in the decision-making process and determines the selection of the specific treatment design. The choice of correct fusion levels in AIS is complex and perfect radiographic planning algorithms are needed to aid in making that decision. In this article, a complete discussion was presented on radiological preoperative aspects of AIS, such as the Cobb angle, frontal and sagittal balance, curve pattern Lenke classification, and the length and levels of fusion. We intended to present a typical way of radiologic preoperative evaluation of patients in the Department of Orthopaedics of the Medical University of Gdansk (Dpt of Ort, MUG) scheduled for the posterior corrective surgery due to severe AIS.

**Key words:** Adolescent Idiopathic Scoliosis, radiographs, Cobb angle, curve, fusion, instrumentation, Lenke Classification, Center Sacral Vertical Line, frontal sagittal balance

### Streszczenie

Głównymi celami leczenia operacyjnego chorych ze Skoliozą Idiopatyczną Dorastających (SID) są: bezpieczna korekcja we wszystkich płaszczyznach z odtworzeniem prawidłowego balansu, z jak najmniejszą ilością kręgów objętych stabilizacją i spondylodezą. Niezwykle istotnym aspektem skutecznego i odpowiednio dobranego leczenia operacyjnego deformacji kręgosłupa oraz prawidłowego doboru poziomu stabilizacji jest właściwe radiologiczne planowanie przedoperacyjne. W poniższym artykule przedstawiono aspekty takie jak: kąt Cobba, balans w płaszczyźnie strzałkowej i czołowej, klasyfikację wg Lenke i inne, a także omówiono szereg czynności następujących po sobie z wykorzystaniem radiologicznych technik cyfrowych przeprowadzanych rutynowo w planowaniu przedoperacyjnym w Klinice Ortopedii i Traumatologii Narządu Ruchu Gdańskiego Uniwersytetu Medycznego (GUMed).

**Słowa kluczowe:** Skolioza Idiopatyczna Dorastających, rentgenogram, kąt Cobba, skrzywienie, spondylodeza, stabilizacja, klasyfikacja wg Lenke, Centralna Linia Krzyżowa, balans w płaszczyźnie strzałkowej i czołowej

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## Introduction

Although Adolescent Idiopathic Scoliosis (AIS) is the most common spinal deformity, its etiology remains unclear. AIS, is typically seen in girls between 11 and 18ys, and a right-sided thoracic curve is most common. Delayed diagnosis can result in severe deformities, which affect the coronal and sagittal planes, as well as the rib cage, waistline symmetry, and shoulder balance [1]. Clinically significant curves of more than 40 degrees of Cobb angle are the indication for the surgical correction. The major surgical goals in the treatment of adolescent idiopathic scoliosis (AIS) include safely obtaining correction of all aspects of the deformity and providing good coronal and sagittal balance with as few fused motion segments as possible [2,3]. Controversy surrounds clinical recommendations for evaluating and managing patients with a wide range of curve sizes [4]. Patient radiographic evaluation is an essential point in the decision-making process and determines the selection of the specific treatment design [5]. In this article, a complete discussion was presented on radiological preoperative aspects of AIS, such as the Cobb angle, frontal balance, axial rotation, curve pattern classifications, and sagittal configuration. We intended to present a typical way of radiologic preoperative evaluation of patients in the Department of Orthopaedics of the Medical University of Gdansk (Dpt of Ort, MUG) scheduled for the posterior corrective surgery due to severe AIS.

## Method

Defining a treatment plan for scoliosis is multifactorial. It involves a clinical and a radiographic evaluation and a detailed discussion with the patient and the family. Prior to surgical correction, all patients undergo a comprehensive evaluation, which consists of a patient history, and physical and neuro-orthopedic examinations performed by one of the two orthopedic spinal surgeons working in (Dpt of Ort, MUG). Clinical photos without any clothing on the trunk (underwear only) are routinely taken during the clinical examination. They allow documentation of visual and structural components of scoliosis. Usually, five views are mandatory: upright posterior, anterior and lateral (both sides) trunk and forward bend posterior for the rib hump evaluation (Fig.1a-e).

Routine preoperative radiological evaluation includes: high quality standing long cassette postero – anterior (PA) and lateral radiographs of the spine including the pelvis and C7 vertebrae to show the true position of the spine, both side bending on postero – anterior radiographs and traction radiographs in supine position. A postero – anterior radiograph significantly reduces radiation exposure to the breasts and thyroid tissue. If there is a leg length discrepancy, radiographs are taken with a proper block under the shorter

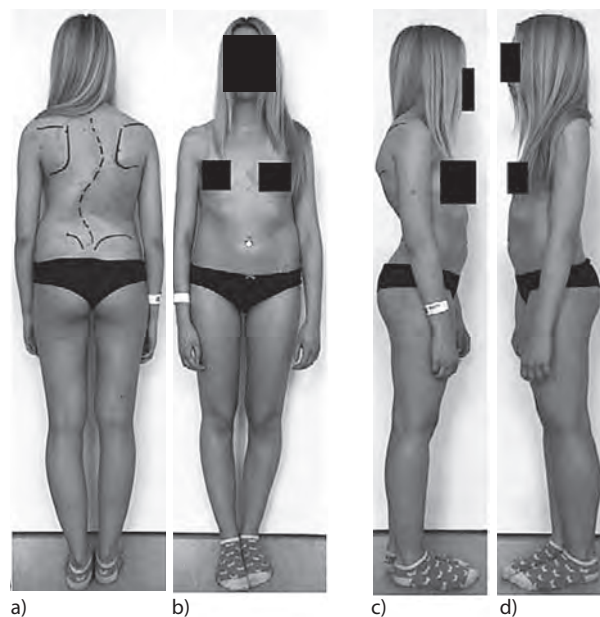


Fig. 1. Clinical photos taken during the clinical examination: a) upright posterior, b) anterior, c,d) lateral (both sides), e) forward bend posterior for the rib hump evaluation.

extremity to level the pelvis. The patient stand with their knees extended, with elbows bent and arms at approximately 60-70° angle to the vertical axis of the body [6] (Fig.2a-d.). The same standing PA and lateral radiographs of the entire spine are also taken postoperatively and during follow-up.

## Results and discussion

The first step when describing scoliosis is numbering the spinal segments, which is relatively easy when the patient's spinal anatomy is normal. We start numeric labeling on standing PA and lateral radiographs from the cervical part of the spine, that is seldom involved in the AIS deformity.

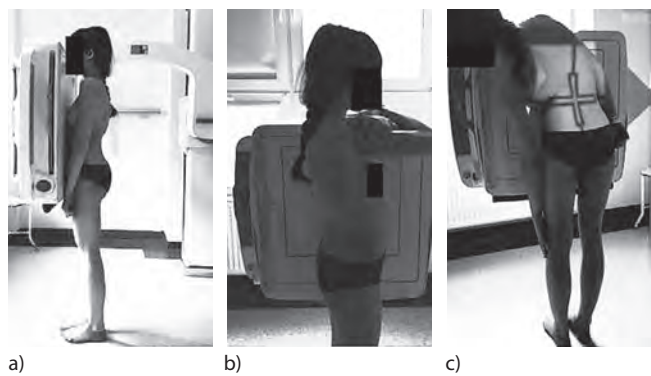


Fig. 2. Preoperative radiological examination technique: a) standing posteroanterior, b) lateral radiographs, c) both side bending on postero – anterior radiographs, d) traction radiographs in supine position

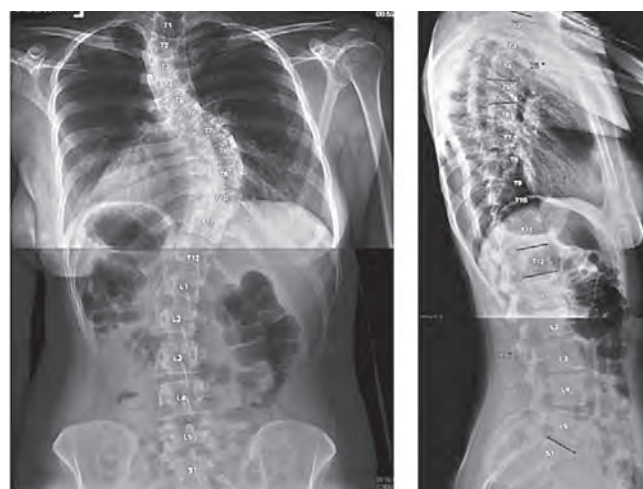
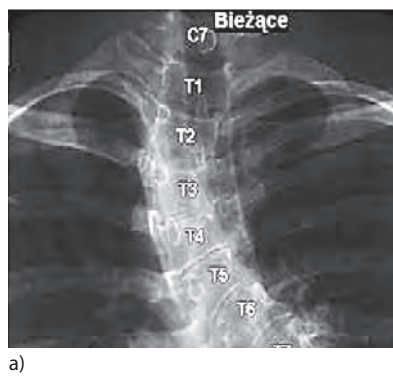


Fig. 3. Numeric labeling on standing PA and lateral radiographs from the cervical part of the spine (see in text)

We recognize T1 as the first vertebra with a pair of associated ribs. All vertebrae distal to T1 with associated ribs (usually 12) we label as thoracic (Fig.3a,b.). One of the most important things in planning for surgical correction of AIS is to decide which curves to include in the fusion. Structural curves should almost always be included. All AIS curve types consist of one primary structural or major curve and one or two compensatory curves that may or may not be structural [7]. So the second step of radiographic evaluation is to identify the primary and secondary curves. For this purpose we use Lenke classification, which allows a reproducibly accurate classification of AIS [8]. First, the regional curves must be identified as follows: proximal thoracic (PT), main thoracic (MT), and thoracolumbar/lumbar (TL/L) curves.

We define particular curve regarding of its apex. For the proper classification of the curve, we determine the structural or non-structural quality of each of the three curves. Curve is considered structural if it is 25° or more of Cobb angle on the standing PA radiograph and does not bend out (on the side-bending radiographs) or to correct (on traction radiographs) to less than 25° of Cobb angle [5]. The Cobb angle we measure between the superior surface of the proximal and in-

ferior surface of the distal end vertebra maximally tilted into the curve (Fig.4a-d.). Minor curve < 25° on the standing PA radiograph by definition is considered nonstructural [4-6,8]. The major curve is always considered to be structural and it is the MT or TL/L, whichever is the largest curve. The next step is to classify the scoliosis regarding to the Lenke Classification. This system is composed of six major curve patterns that can be further divided into 42 subtypes [4,5,8]. In (Fig.5a-c.) we present three different types of curve patterns of our AIS patients scheduled for the operative treatment.

Selective fusion involves fusing only one of two curves that cross the midline. Selective fusion may save motion segments, which is especially important in the lumbar spine [9]. In the next step we assign a particular lumbar modifier. To do so one has to draw a Center Sacral Vertical Line (CSVL) that is a line drawn upward from the center of the sacrum perpendicular to the line joining the iliac crests. Then we assess the apex of each of the curves. It is the most horizontal and laterally deviated vertebra or disc from the midline. If the CSVL passes between the pedicles of the apical lumbar vertebra, the lumbar modifier A is assigned. If the CSVL falls between the medial edge of the concave pedicle and the most



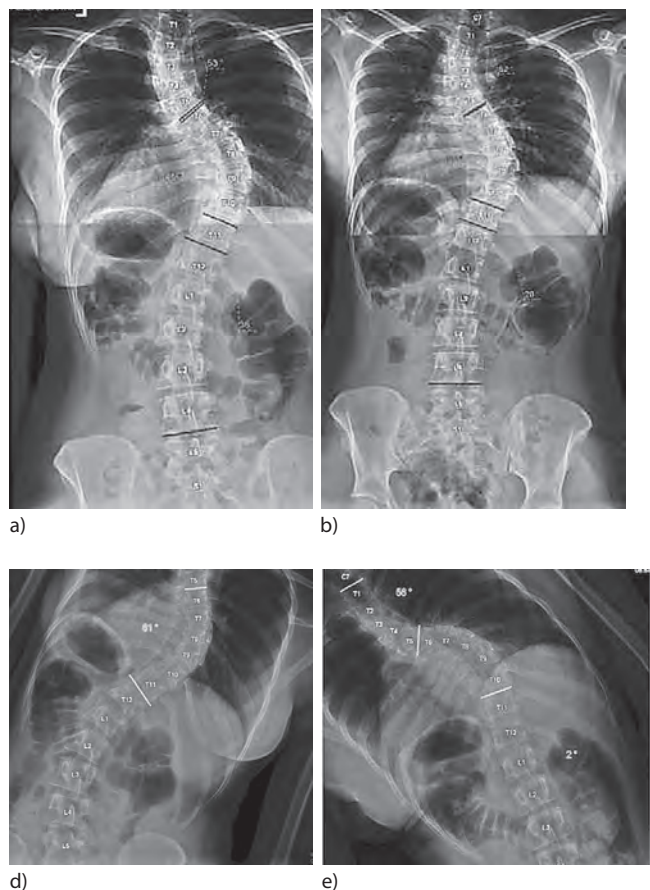


Fig. 4. The Cobb angle measurement on: a) standing PA, b) supine traction, c,d) both side bending on postero – anterior radiographs

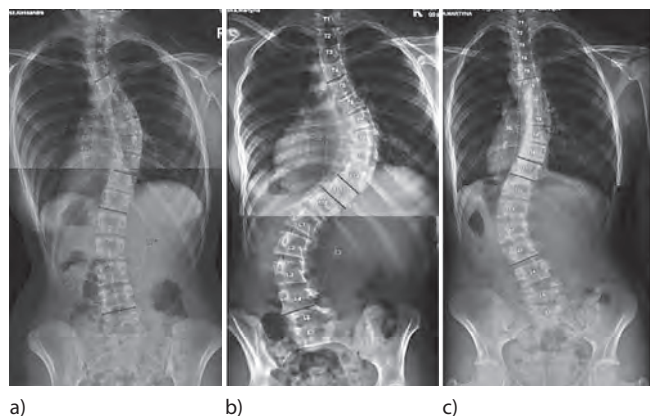


Fig.5. The examples of scoliosis major curve patterns regarding to the Lenke Classification: a) IB, b) III, c) V

lateral part of the vertebral body on the apical lumbar vertebra, the lumbar modifier B is assigned. If the CSVL does not touch the lateral edge of the apical lumbar vertebra, the lumbar modifier C is assigned (Fig.6a,b).

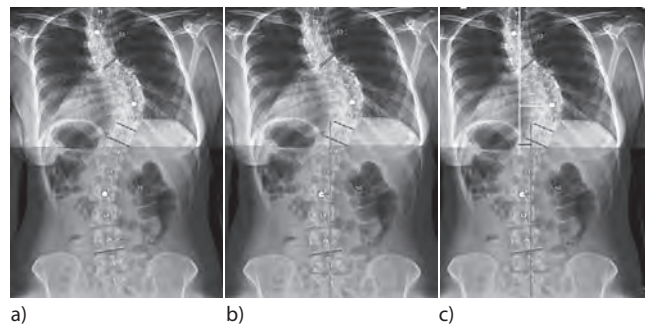


Fig.6. A lumbar modifier and frontal balance assignment: a) assessment of the apex of each of the curves, b) Center Sacral Vertical Line (CSVL), c) C7 plumbline (C7PL) and negative frontal balance

Further on we drop the “C7 plumbline” (C7PL) from the middle of the C7 vertebral body and we draw it parallel to the vertical edge of the radiograph. Then with CSVL drawn from the middle of S1 upwards and parallel to the vertical edge of the radiograph we can evaluate the frontal balance as well as apical vertebral translation AVT (the distance between C7PL and the apex of the thoracic curve and between CSVL and apex of the Th/L curve). Frontal balance can be positive when C7PL is on the right side of CSVL and negative when on its left side (Fig.6c.). Paralelly we evaluate the saggital balance of the spine on lateral radiographs and the thoracic sagittal modifier (degree of thoracic kyphosis on the other words) that we determine by evaluating the Cobb angle between T5 and T12. If it is less than 10 degrees, the sagittal thoracic alignment is considered to be hypokyphotic and we assigne a minus modifier. If it is between 10 and 40 degrees, we consider it to be normal thoracic kyphosis. If we find the sagittal Cobb angle between T5 and T12 greater than 40 degrees, we consider is hyperkyphotic and we assigne a plus modifier. Saggital balance we evaluate by the distance between the line drawn from the postero – superior corner of S1 perpendicular to the vertical edge of the radiograph and the C7 Plumb Line (C7PL) drawn from the center of C7 and also perpendicular to the vertical edge of the radiograph [10,11]. Additionally if C7PL is more anteriorly or posteriorly to the central line we assigne positive or negative saggital balance respectively (Fig.7a,b.). In addition, the end, stable and neutral vertebrae are identified on standing and traction radiographs which assists in selection of fusion levels during planned surgery [12]. The end vertebrae (EV) are the most tilted vertebrae at the cephalad and caudal ends of a curve. Stable vertebra (SV) refers to the inferior vertebra, which is most closely bisected) by the CSVL on standing radiograph. The neutral vertebra (NV) is the most cephalad vertebra below the apex of the major curve whose pedicles are symmetrically positioned within the vertebral body (Fig.8a,b).

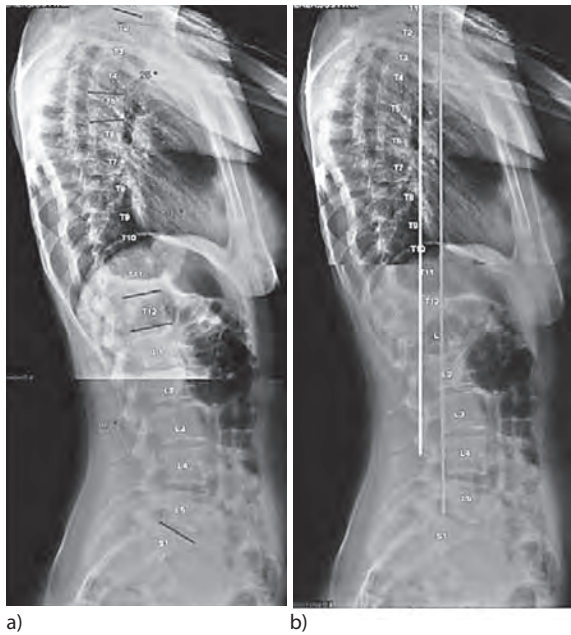


Fig. 7. The lateral radiograph evaluation: a) the thoracic sagittal modifier (thoracic kyphosis) and lumbar lordosis, b) the sagittal balance of the spine

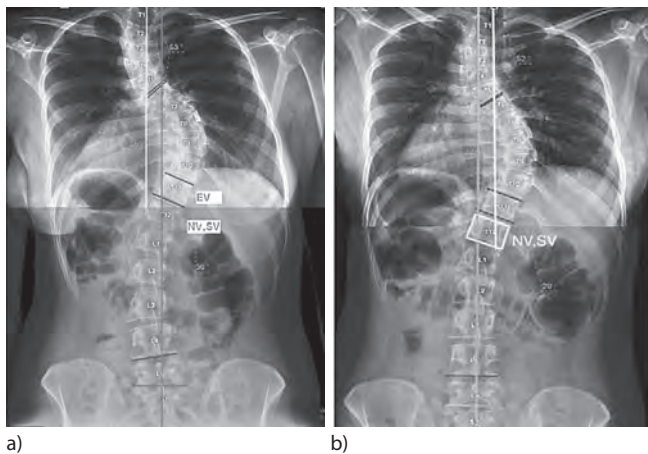


Fig.8. The end, stable and neutral vertebrae identified on: a) standing and b) traction radiographs

Correct identification of fusion levels in surgical planning for the management of adolescent idiopathic scoliosis is a complex task. Again the Lenke classification is the benchmark system that we use routinely for this purpose. Having all this information previously gathered we can now identify the Lowest Instrumented Vertebra (LIV) and the Upper Instrumented Vertebra (UIV) of our planned fusion [13,14]. The long-term effect of saving distal fusion levels on the severity of back pain and disc degeneration was observed by some authors [13,15]. During our planning we generally agree that a spinal fusion should be as short as possible. In our opinion saving distal disk spaces improves the long-term outcome. Motion preservation is less important factor in selecting the UIV because the thoracic spine is rigid by nature due to the rib cage and sternum. More important concerns in selecting

the UIV are preventing postoperative shoulder imbalance and proximal junctional kyphosis (PJK) [16]. In general at our department, we include all structural curves in the fusion. The UIV should not be subjacent to a kyphotic disk. We usually select T2 for UIV when the left shoulder is elevated, T4 when depressed and T3 when left and right shoulders are the same level. When lumbar modifier is A, we select for the LIV the vertebra touching the CSVL. When lumbar modifier is B or C, we usually select the thoracolumbar SV as the LIV. However, not all curves can be managed using the rules mentioned above, thus the treatment must be individualized to each patient. Although we strive to avoid lumbar fusion if possible, leaving mobile discs below the LIV (Fig.9a-c).

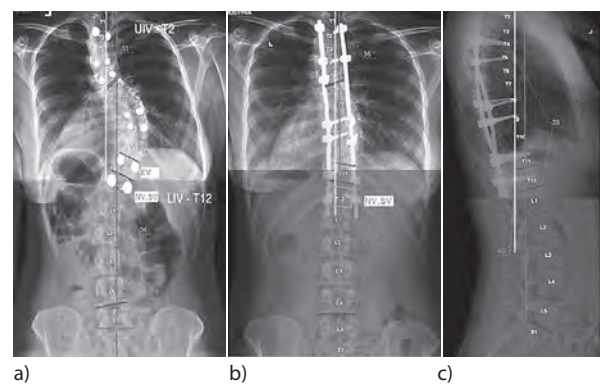


Fig. 9. a) Correct identification of fusion levels, the Lowest Instrumented Vertebra (LIV) and the Upper Instrumented Vertebra (UIV) of our planned fusion, b,c) postoperative standing PA and lateral radiographs

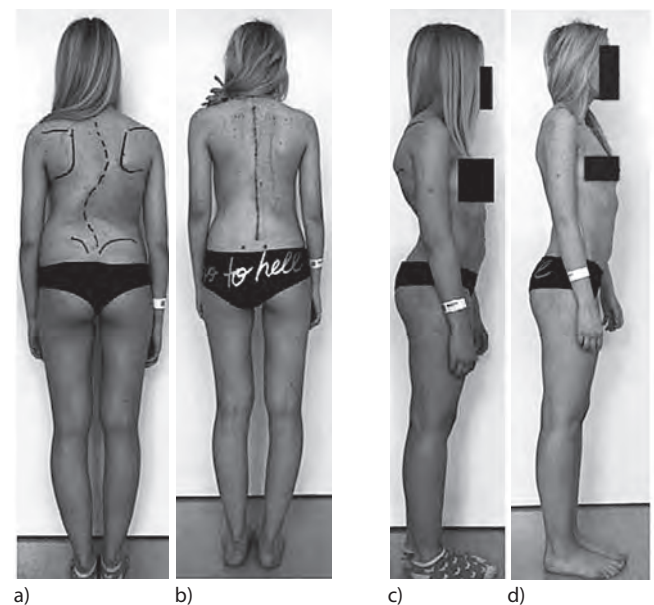


Fig.10. Final clinical photos of the patient – upright posterior a) preoperative, b) postoperative and lateral c) preoperative, d) postoperative





## Conclusions

Proper pre operative radiographic planning is mandatory for decision making in the surgical treatment of AIS.

The Lenke Classification is the benchmark system that we use routinely for this process.

The choice of correct fusion levels in AIS is complex and perfect radiographic planning algorithms are needed to aid in making that decision.

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## PRACA ORYGINALNA

Ortopedia dziecięca

# Surgery technique of an anatomical MPFL reconstruction using allograft in children with recurrent patellar dislocation

## Technika chirurgiczna anatomicznej rekonstrukcji MPFL przy użyciu alloprzeszczepu u dzieci z nawracającym zwichnięciem rzepki

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### Abstract

**Purpose:** The objective of the study was to demonstrate the surgical technique of medial patellofemoral ligament reconstruction with a cadaver's allograft in children.

**Methods:** 15 children in age 12 to 15 years with recurrent patellar dislocation underwent MPFL reconstruction. Surgery was performed using cadavers' allograft. The mean age of the patients was 13.1 years and the mean follow-up was 14 months. All patients were evaluated clinically and radiologically. Kujala score questionnaire was used pre-operatively and 18 to 24 months post-operatively to estimate the results of our treatment.

**Results:** We present details and efficiency of the mpfl reconstruction with cadaver's allograft. The results in 96% of patients were rated as good or very good on the basis of Kujala score.

**Conclusions:** In our opinion described technique is simple and allows sparing hamstring muscles for further reconstruction. It also reduces time of the surgery and post-operative pain with a good outcome in follow – up results.

**Key words:** recurrent patellar dislocation, MPFL, children

### Streszczenie

**Cel pracy:** Autorzy przedstawiają chirurgiczną technikę anatomicznej rekonstrukcji MPFL u dzieci z nawrotowym zwichnięciem rzepki.

**Metody:** 15 dzieci w wieku od 12 do 15 lat z nawracającym zwichnięciem rzepki poddano rekonstrukcji MPFL. Średni wiek pacjentów wynosił 13,1 lat, a średni okres obserwacji 14 miesięcy. Wszystkich pacjentów poddano ocenie klinicznej i radiologicznej. Do oceny wydolności stawu kolanowego użyto kwestionariusz Kujala-Score. Zastosowano go przed przed zabiegiem i od 18 do 24 miesięcy po operacji.

**Wyniki:** Wyniki 96% pacjentów zostały ocenione jako dobre lub bardzo dobre.

**Wnioski:** Naszym zdaniem technika jest prosta, skuteczna i pozwala zachować mięśnie zginacze do ewentualnych dalszych zabiegów operacyjnych. Skracają również czas zabiegu operacyjnego i ból pooperacyjny.

**Słowa kluczowe:** nawrotowe zwichnięcie rzepki, MPFL, dzieci

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## Introduction

The Medial Patellar Ligament (MPFL) plays an important role for the proper mechanical stability of patello-femoral joint. MPFL is the primary passive stabilizer preventing lateral displacement of the patella [1]. Patellar luxation is in most cases with MPFL injury. Sometimes it occurs as simple lengthening but often appears to be a complete rupture of the ligament. Recurrent patellar dislocation is usually associated with knee dysplasia of varying extent [2, 3]. Several methods of MPFL reconstruction has been described for children [4].

The incidence of recurrent patella dislocation is approximately 6 per 100,000 of the general population in patients aged 10-17 of either gender [5]. MPFL reconstruction in children with recurrent patellar dislocation usually leads to good results with low complication rates [6].

## Purpose of the study

The objective of the study was to demonstrate surgical technique and results for treatment of recurrent patellar dislocation in children.

## Materials and methods

**Patients:** 15 children (10 girls and 5 boys, 12 to 15 years old) with recurrent patellar dislocation underwent MPFL reconstruction with using described technique. The mean age of the patients was 13.1 years and the mean follow-up was 15 months (18 to 24). All patients were evaluated clinically and radiologically. Inclusion criteria included minimum second-time or recurrent patellar dislocation and tibial tuberosity – trochlear groove (TT – TG) distance of less than 20 mm. Kujala score questionnaire was used pre-operatively and 10 to 24 months post-operatively to estimate the results of the treatment [7].

**Surgical technique:** All children were operated using the same technique and by the same surgeon. Allografts were acquired from Tissue Bank in Katowice, Poland. An 8 to 12 mm wide, 2 mm thick and 5 to 7 cm long strips from the aponeurosis of tensor fasciae latae muscle were prepared (Fig.1). The ends of graft were prepared with nonabsorbable suture by use of a baseball-suture technique. A 1.5 to 2 cm incision was made over the medial aspect of patella and the periosteum and bone were exposed. Then two oblique canals 2 mm wide in diameter and 1 cm long were drilled in the medial aspect of patella in the upper and middle-third junctions. Allograft was attached with sutures that were drawn through those canals. Afterwards, a path was created by blunt dissection between the medial aspect of patella and the femoral condylar incision (Fig. 2). An incision, about 3-cm long, extended



Fig. 1. Cadaver's allograft harvested from tensor fasciae latae.



Fig. 2. Placement of an allograft.

from the adductor magnus tendon to the medial epicondyle. Proper femoral insertion of the MPFL was identified under fluoroscopic control (Fig. 3). Femoral attachment was located 2 mm anterior and 4 mm distal to adductor tubercle, always below growth plate level and fixed with titanium anchor. The graft was pre-stretched to obtain its proper tension that secured the intended position of patella. Then patellar tracking was assessed by taking the knee through a full range of motion and the wound was closed in layers. Drainage was used and compression dressing was applied.

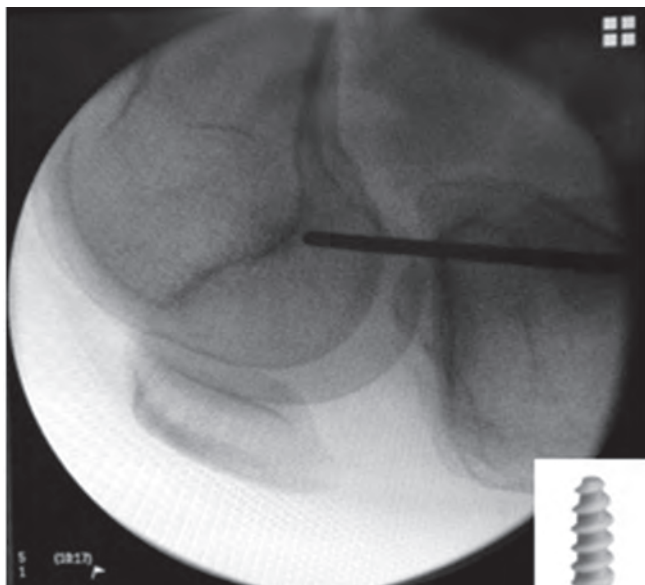


Fig. 3. Femoral attachment and placement of an anchor.

Statistical analyses: Statistical analysis was done using student's t-test where  $t=49,1412$ . The P value for the Kujala scores were significant at a confidence limit of  $P<0.001$ . All statistical calculations were performed using 10.0 STATISTICA software (StatSoft, Poland).

## Results

We did not notice any serious complications. In follow – up study there was any redislocation. In all patients an ultrasound examination were performed to visualized the dynamic function of graft used as reconstructed MPFL. The Kujala score was also significantly improved from  $47.9 \pm 5.7$  points preoperatively (range 40 to 69 points) to  $89.7 \pm 5.8$  points post-operatively (range, 76 to 100 points) ( $P<0.05$ ). According to patient-perceptive symptoms, obtained results in the 96% of patients were rated as good or very good. All children returned to full activity.

## Discussion

There are a lot of surgical procedures to treat recurrent patellar dislocation with no indication of advantages of a specific graft over the others. [8]. Semitendinosus and gracilis hamstrings are most popular structures used as grafts for reconstructive MPFL in children [9]. Others use a strip of quadriceps or tensor fascia latae muscle [10]. Isolated medial transfer of TT has produced poor results [11]. Therefore, MPFL reconstruction became a widely accepted technique for restoration of proper patella tracking and patellofemoral stability as well.

In described surgical technique we used a cadaver's allograft harvested from the tensor fasciae latae muscle. We believe that application of such graft allows to spare hamstring muscles for further reconstruction, considerably reduce time of the surgery and post-operative pain. In our surgical technique we followed the idea of Sanchis who proves that the essential component of such procedure is a femoral attachment of the MPFL which ought to be localized distal to the apex of the adductor tubercle and parallel with the long axis of the femur. Femoral attachment of reconstructed MPFL is always centered under the level of the growth plate. Nowadays reconstruction of the MPFL to treat recurrent patellar dislocation in children has become a common, however, the choice of graft and surgical technique remains a subject of continued discussions. In our study, which contained children with MPFL reconstruction with an allograft, we had no serious complications. Our follow-up mean Kujala score is comparable to other studies where MPFL reconstructions lead to a good postoperative patellar stability with redislocation rates less [12]. Our article presents details of surgical technique for MPFL reconstruction in the patients with open physes. In this age group there are only few studies that compare different surgical techniques of MPFL reconstruction with good early outcomes [13].

## Conclusions

There are some techniques for anatomical MPFL reconstruction in recurrent patellar dislocation in children. The presented surgical procedure shows some factors that can be valuable for our patients. Application of a such allograft allows to spare hamstring muscles for further reconstruction and reduces time of a surgery. Presented reconstruction turned out to be very efficient with good early follow – up results.

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## PRACA ORYGINALNA

Ortopedia dziecięca

## Knee arthroscopy in children and adolescents

## Artroskopia stawu kolanowego u dzieci i młodzieży

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## Abstract

With the dynamic growth of sports culture comes an increased percentage of children participating in sport activities and exposed to a significant risk of injury. Simultaneously, the progress made in arthroscopic techniques has led to the development of a new field in medicine, i.e. paediatric sports medicine. Nevertheless, arthroscopic procedures in children give rise to much controversy among health professionals who argue against them mainly citing the lack of objective indications to perform arthroscopic surgery of the knee in skeletally immature patients. The purpose of this publication is to evaluate the diagnostic and therapeutic approaches to traumatic injuries of the knee in patients during the period of active growth, where arthroscopy has proven to be an appropriate and valuable therapeutic method. The paper also defines indication criteria for arthroscopic treatments and outlines the surgical techniques in use.

**Key words:** arthroscopy, knee injuries, adolescents, children, anterior cruciate ligament reconstruction

## Streszczenie

Wraz z dynamicznym rozwojem kultury sportowej, wzrasta odsetek dzieci uprawiających sport obciążony wysokim ryzykiem urazowym. Jednocześnie postęp jaki dokonał się w artroskopii, stworzył nową dziedzinę medycyny jakim jest dziecięca medycyna sportowa. Zabiegi artroskopowe u dzieci budzą jednak wiele kontrowersji wśród lekarzy, którzy swoje negatywne stanowisko argumentują głównie brakiem obiektywnych wskazań do wykonania operacji artroskopowej stawu kolanowego w okresie dojrzewania szkieletowego. Zadaniem tej publikacji jest ocena metod diagnostycznych i leczniczych stosowanych w pourazowych uszkodzeniach stawu kolanowego u osób w okresie wzrastania, u których to artroskopia okazała się właściwą i wartościową metodą terapeutyczną. W pracy określono również wskazania do artroskopowych zabiegów leczniczych i przedstawiono zarys wykorzystywanych technik operacyjnych.

**Słowa kluczowe:** artroskopia, urazy stawu kolanowego, młodzież, dzieci, rekonstrukcja więzadła krzyżowego

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## Introduction

Indications for arthroscopic procedures of the knee joint in children continue to excite much controversy. Opinions on this topic differ widely: from claims that there are no indications whatsoever, given children's high capacity for healing, to propositions that diagnostic/therapeutic arthroscopy should be performed in all knee injuries with concomitant hemarthrosis. Current medical knowledge allows for a rational approach to the assessment of indications and qualifying patients for arthroscopic procedures.

This overview summarises the present state of our knowledge on knee injuries and indications for treatment with the use of arthroscopic methods, so as to support orthopaedic doctors in making better informed decisions regarding arthroscopic treatments of knee joint injuries in children.

Any decision to perform an arthroscopy in a child should be preceded by an in-depth analysis of findings from the medical history, physical examination and imaging tests. Due to the development of diagnostic imaging methods, such as ultrasound and magnetic resonance, diagnostic arthroscopy in children is very rare. However, the difficulties involved in both clinical examination and additional testing in children must be noted. According to studies, the accuracy of preoperative diagnosis in children ranges from 31.25% to 90% [1,2]. That is why the experience of the professional qualifying the child for an arthroscopic procedure is of vital importance. The internal injury of the knee joint presenting with hemarthrosis, according to some authors, constitutes an indication for an urgent arthroscopic procedure on an emergency basis. The most commonly involved pathologies are osteochondral fractures, patellar dislocation, injuries of the anterior cruciate ligament (ACL) and of the menisci [1-4].

## Cruciate ligament injuries

Injuries of the cruciate ligament of the knee affect 0.6% of children. It has been demonstrated, however, that participation in organised sports 4 or more times a week corresponds to an increased hazard ratio for a cruciate ligament injury – amounting to as much as 8.5% for girls and 4% for boys [5,6]. For this reason, special emphasis is placed on the prevention of anterior cruciate ligament (ACL) injuries through neuromuscular training, particularly in girls. This is because it was observed that their risk of ACL injury is even 8 times higher than in boys [6].

About 50% of ACL injuries present with hemarthrosis. Physical examination, comprised of the Lachman test and pivot-shift test, may fail to detect up to 75% of ACL injuries, hence in the case of doubt the examiner is advised to broaden diagnostics by including magnetic resonance imaging (MRI) [7]. Advances in magnetic resonance imaging techniques

using the right sequences to visualise the ACL have made it possible to achieve diagnostic sensitivity for ACL injury in children of up to 95% [8,9].

ACL reconstruction in children remains a controversial topic. Some authors note that early reconstruction is necessary to avoid meniscal and chondral damage secondary to chronic ligamentous instability [8,10-13]. In numerous studies, authors recommend lifestyle change and modifying sports activity with the aim of postponing the surgery until skeletal maturity is reached. The merits of well-structured rehabilitation are also mentioned [14,15]. According to Kocher et al., conservative treatment is preferred in children under the age of 14 suffering from a partial ACL tear, with negative results from the Lachman and pivot-shift tests. Ligament reconstruction is preferred in older children where more than half of the ACL fibres are torn or where the damage is predominantly in the posterolateral ACL [16].

A meta-analysis conducted by Ramski et al. demonstrated superior clinical outcomes of early reconstruction of a complete ACL tear [17]. The decision to pursue surgical treatment raises further questions, related to issues such as the timing of the operation, the technique to be employed, the graft type and harvesting location. Delaying the procedure beyond 12 weeks is associated with a greater risk of damage to the menisci or articular cartilage, particularly in the lateral compartment of the knee joint. The decision to delay the surgical procedure is based on the assessment of skeletal maturity and the amount of growth remaining. Concerns about the potential disruption of the growth plate and possible angular deformities of the limb have led to the development of numerous intra-epiphyseal techniques. A number of authors have found trans-epiphyseal procedures to be safe due to the minimal damage to the growth plate. The literature, however, reports cases of complications in the form of growth disturbance, the risk of which increases with transphyseal graft stabilisation, large tunnels (12mm+), extra-articular lateral tenodesis reconstruction, application of sutures near the tibial tuberosity, tissue preparation in the area of the perichondrial ring of LaCroix [9,18-20]. Treatment algorithms have been developed to identify the technique of preference depending on the patient's bone age, stage of puberty, and the amount of growth remaining [9,21,22]. Regarding graft choice, the use of autografts is preferred due to the higher failure rate observed with allografts. No differences in treatment outcomes were observed depending on the graft harvesting location [8].

As an alternative to reconstruction, a ruptured anterior cruciate ligament can be repaired using the "internal bracing" method, which involves temporary ligament augmentation with an implanted polyethylene tape [23].

The literature reports only isolated cases of ligament injuries accompanying ACL rupture which would require reconstruction. Mascarenhas et al. described the reconstruction of the ACL and the posterolateral structures of the knee in a child [24].



Injuries of the posterior cruciate ligament in children are rare, but may lead to posterior knee instability requiring surgical intervention. Most often, such injuries tend to result from an avulsion, while intraligamentous damage is extremely rare [25]. The literature describes cases of operative treatment of posterior instability, including a PCL reconstruction in a boy as young as 5 [26,27].

Postoperative rehabilitation of the young patient is conditional upon a good rapport, and so it requires that the physiotherapist have experience in working with children. Help from the parents often turns out to be indispensable, too. As many studies have shown, return to the same level of sports participation as before the ACL injury ranges between 50 and 97% [8,28].

## Meniscal injuries

Injuries of the menisci of the knee present with accompanying hemarthrosis in 32-47% of cases. They are the third most common cause of post-traumatic knee hemarthrosis [2,3]. Our understanding of the important functions of the menisci has changed the approach to the management of such injuries. At present, the preferred treatment method is meniscus repair and preservation, once it was proven that meniscectomy significantly accelerates the development of degenerative changes in the knee joint. Due to the remote consequences of meniscectomy, special care is taken to preserve as much meniscal tissue as possible, especially in young patients. Meniscal injuries in children tend to represent the complex tear pattern (28%). In a study by Sieh et al., surgical repair was possible in about 50% of children and adolescents with a damaged meniscus [29]. According to a study by Kraus et al., all meniscal injuries in children with open physes were amenable to repair, regardless of the location of the tear. In 84% of patients, the meniscus healed. It was also observed that better outcomes were associated with simultaneous reconstruction of the ACL injury which accompanies 40–60% of meniscal injuries. In a study by Krych et al., meniscus repair was successful in 84% of simple tears, 59% of displaced bucket-handle tears, and 57% of complex tears. In the case of isolated complex tears of the meniscus, a success rate of as little as 13% was reported [3,30,31]. Due to the higher healing potential of meniscal tears in children, the literature describes positive treatment outcomes in the repair of extensive meniscus tears such as the luxation of the posterior horn or bucket-handle tears [32-34]. There is also evidence of positive outcomes in the arthroscopic treatment of avulsion fractures of the posterior root of the medial meniscus using the ACL reconstruction instrumentation [35]. Moreover, it was found that even if the primary meniscus repair fails to heal, revision procedures may produce acceptable clinical results [3].

In children with open physes discoid meniscus damage is found more often than in people at a later stage of development [29]. According to the modified Watanabe classification, there are four types of discoid menisci [36]. Watanabe's type I discoid meniscus covers the entire surface of the lateral condyle, while type II covers a part thereof. In type III, the posterior meniscotibial attachment – the Wrisberg ligament – is missing. Monllau modified the Watanabe classification by adding a type IV, which corresponds to a rare ring-shaped meniscus (table 1).

Table 1. Modified Watanabe classification of discoid lateral meniscus according to Monllau.

Type	Lateral discoid meniscus
I	complete
II	incomplete
III	Wrisberg type
IV	ring-shaped

If asymptomatic, the discoid meniscus does not require treatment. In children, it can produce symptoms of the snapping knee syndrome, as well as pain. This may be caused by the abnormal mobility of the meniscus, in the absence of the posterior root in type III. Such symptoms may also be present with type I or II meniscus. Therapy involves meniscopectomy and partial resection, repair of any existing tears and reattachment to the posterior joint capsule if the posterior root is missing [3,37-41].

## Intercondylar eminence fractures

Intercondylar eminence fractures usually result from avulsions and involve the tibial attachment of the anterior cruciate ligament. The mechanism of the injury is similar to ACL injury in adults, however, due to the presence in children of collagen fibres blending from the anterior cruciate ligament to the perichondrium and epiphyseal cartilage, avulsion fractures are more common. In adults, the ligament inserts directly into the bone via Sharpey's fibres, hence in that patient group the injury tends to affect the ligament itself. Intercondylar eminence fractures are a rare knee injury accounting for 3 out of 100,000 fractures in children, most frequently between the ages of 8 and 17. The intercondylar eminence fracture in children, unlike with adults, is most often an isolated injury. The most commonly used classification is the Meyers and McKeever classification as modified by Zaricznyj, identifying four types of fractures (table 2).





Table 2. Modified Meyers and McKeever classification according to Zaricznyj

Type	Intercondylar eminence fracture
I	non- or minimal displacement, under 2 mm
II	moderate displacement of the anterior third or half of the affected bone, with intact posterior hinge
III A	large displacement without rotation
III B	large displacement with rotation
IV	comminuted fracture

Non-operative treatment is preferred in the majority of non-displaced type I fractures. Depending on the patient's age, treatment may involve knee immobilisation for 4–6 weeks in up to 30-degree flexion or in extension. The approach to the management of type II–III fractures has evolved over the past 10 years towards operative treatment. It allows for a release of interpositioned tissues, elimination of mechanical obstacles preventing the restoration of the full range of motion, reduction of the duration of joint immobilisation, and minimisation of the risk of non-union. Operative treatment of type II fractures with partial displacement is recommended when the joint surface is involved, when the knee is unstable, or when reduction is impossible due to tissue interposition. Surgical intervention is always indicated in type IIIA, IIIB and type IV fractures, in the light of current publications. At present, the operative method of choice will be based on the arthroscopic approach. It makes it possible to use minimally invasive techniques, as well as being associated with better long-term treatment outcomes, earlier joint mobilisation minimising the risk of stiffness and decreased range of motion, and also shorter hospital stays compared to the “open surgery” approach. Early mobilisation helps reduce the risk of arthrofibrosis, one of the most common complications. Fracture fixation may be performed using a number of methods described in the literature, including: Kirschner wires, sutures, anchors, screws with washers or Herbert screws. Screws are usually employed to fix larger bone fragments, while sutures are preferred in the treatment of fractures with small fragments [42-45].

## Chondral defects

Osteochondritis dissecans (OCD) is most commonly found in the knee. It may present with pain and effusion in the knee, and at later stages with symptoms related to the presence of loose body fragments. The most common sites for OCD include the medial femoral condyle (70–80%), followed by the lateral condyle (15–20%) and the patella (5–10%). Patients with a discoid meniscus bear an increased risk of OCD, in the range of 11%.

OCD treatment in children starts with a trial of conservative treatment provided that no loose bodies were found in the joint space and diagnostic imaging shows that the defect is stable. In such a case, therapy involves modification of physical activity and reduced weight bearing in the limb. Conservative measures may be continued for 3–5 months. If conservative treatment fails and in the case of unstable OCD, operative treatment is indicated.

Arthroscopic methods are the treatment of choice for OCD. Drilling techniques have been described for the treatment of stable lesions: retro-articular, retro-articular through the intercondylar notch and trans-articular directly through the cartilage. Up to 91% of OCD lesions heal with retro-articular drilling. However, none of the above-mentioned drilling modalities was demonstrated to be clearly superior to others. These techniques may be augmented with bone transplants. With unstable OCD, fixation is performed using pins or bioresorbable screws [46-49].

Traumatic chondral injuries in children most often accompany patellar dislocation, where they occur in 95% of cases. The treatment algorithm for traumatic chondral injuries includes arthroscopic methods not unlike those used in adult patients, depending on the degree and extent of the injury. For unstable, partial-thickness injuries, articular cartilage may be mechanically debrided using a shaver. In the case of full-thickness defects, in turn, microfractures possibly with the use of biomaterials are used [50].

Osteochondral fractures are much more common in children than in adults. They occur as a result of: patellar dislocation (30–50% of cases), knee sprain with ACL injury (16–40%) or direct trauma. They most commonly tend to affect the lateral femoral condyle or the articular surface of the patella.

The preferred approach to an osteochondral lesion is to reposition the dislocated fragment, if only technically possible. Treatment methods most commonly involve the use of bioresorbable pins or screws or (less common) techniques employing sutures or fibrin glue. These procedures may be performed arthroscopically, if technically possible, or by arthrotomy. Studies have shown that positive results were obtained even when the time between the injury and the procedure exceeded 2 months. Still, the preferred practice is to perform the intervention as early as possible, with 10 days since the injury regarded as the optimal timeframe [51,52].

## Patellar dislocation

In the case of patellar dislocation, arthroscopic techniques support therapies employed to manage the injury itself, but also to prevent recurrent dislocation by mitigating the predisposing factors. The operative treatment of first-time patellar dislocation remains highly controversial. Even though



findings from short-term observation support operative reconstruction of the medial patellofemoral ligament (MPFL), there is no strong evidence to recognise such a procedure as a treatment standard [53-55].

One procedure has recently been gaining significance in the treatment of recurrent or habitual dislocation of the patella – trochleoplasty, which can also be performed arthroscopically [56]. The literature provides no evidence of any major influence on the function of the patellofemoral joint or the prevention of subsequent dislocation as a result of arthroscopic lateral retinacular release used alone [57]. The method does, however, have merit when used in combination with other surgical procedures, such as the tibial tubercle osteotomy or MPFL reconstruction when lateral patellofemoral ligaments are contracted secondary to chronic instability of the patella [58]. Arthroscopic duplication of the MPFL remains controversial, but it appears to produce good outcomes in the presence of appropriate indications and normal anatomy of the patellofemoral joint [59,60].

## Synovial plicae

Folds of the synovial membrane lining the joint (synovial plicae) occur naturally in the knee, but may produce pain symptoms when they become swollen and hypertrophic. The medial plica is most commonly involved. Contributing factors include repeated injury to the knee and overuse. Normal synovial plica may transform into a thick fibrous structure due to the influence of factors accompanying post-traumatic healing processes and inflammation factors. Hypertrophy may cause pain, due to the mechanical irritation of the receptors, as well as chondromalacia. Enlargement of the synovial plica often affects young and active individuals. Conservative treatment produces better results in younger patients with fewer symptoms and is based on reduced weight bearing, anti-inflammatory medication and rehabilitation. Absence of improvement constitutes an indication for arthroscopic complete excision of the overgrown plica. Operative treatment successfully eliminates all of the symptoms in the majority of patients, with as little as 10% observing no significant improvement [2,61,62].

## Conclusions

Arthroscopic treatment when used for appropriate indications is an effective minimally invasive therapeutic method for knee injuries in children. Its most common applications include the treatment of injuries involving cruciate ligaments, cartilage, menisci, intercondylar eminence fractures, patellar dislocation and the plica syndrome.

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## PRACA ORYGINALNA

Kończyna dolna i obręcz biodrowa

# Evaluation of the outcomes of cementless metaphyseal hip arthroplasty in the treatment of hip osteoarthritis depending on the type of articulation used in a mid-term follow-up

## Ocena wyników endoprotezoplastyki bezcementowej przynasadowej stawu biodrowego w leczeniu choroby zwyrodnieniowej stawu biodrowego w zależności od zastosowanej artykulacji stawowej w średnio długim okresie obserwacji

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### Abstract

Osteoarthritis is one of the most prevalent diseases of the locomotor system. Because of its increasing morbidity leading to more and more hip arthroplasty interventions the new types of articulation were developed. The purpose of the study was to evaluate the results of cementless hip arthroplasty depending on the type of the articulation used in patients of the Men's Department of the District Hospital of Trauma and Orthopaedics in Piekary Śląskie in 2009-2011.

**Key words:** osteoarthritis, hip osteoarthritis, hip arthroplasty, metaphyseal hip arthroplasty, ceramic-on-ceramic articulation, Verilast Oxinium articulation

### Streszczenie

Choroba zwyrodnieniowa stawów jest jednym z najczęstszych schorzeń narządu ruchu. Obserwowana w ostatnich latach zapadalność na te schorzenie doprowadziła do coraz większej liczby wykonywanych endoprotezoplastyk oraz rozwoju nowych rodzajów artykulacji stawowej. Celem pracy była analiza porównawcza wyników endoprotezoplastyki bezcementowej przynasadowej stawu biodrowego w zależności od rodzaju zastosowanej artykulacji w średnio długim okresie obserwacji u pacjentów leczonych w Oddziale Męskim Wojewódzkiego Szpitala Urazowego w Piekarach Śląskich w latach 2009-2011.

**Słowa kluczowe:** choroba zwyrodnieniowa stawów, choroba zwyrodnieniowa stawu biodrowego, endoprotezoplastyka stawu biodrowego, endoprotezoplastyka przynasadowa, artykulacja ceramika – ceramika, artykulacja Verilast, Oxinium

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## Introduction

Technological advances of the recent decades have led to the substantial development of medicine. Consequently, life expectancy has significantly increased and the process of population ageing is being observed.

The data presented by the Central Statistical Office of Poland for the year 2013 point to a rapid and substantial increase in the population of people aged 65 years and older. Over 25 years from 1988 to 2013, this number soared from 3,704.5 thousand to 5,672.6 thousand, accounting for an increase by 53.1%. [1]. For this reason, the number of immobile people is also rising. One of the major causes of immobility is the elevated number of new cases of osteoarthritis.

Osteoarthritis means a chronic degenerative joint disease which is characterized by a gradual degeneration of the areas of the affected joint, i.e. the articular cartilage, subchondral region of the bone, joint capsule and other tissues that form the joint. Osteoarthritis is developed very slowly, eventually leading to a substantial limitation of the range of motion of the joint.

The disease is considered as a degenerative process leading to the reduction in the amount of cartilage as a consequence of increased pressure to the joint (overload or joint incongruence). In the nineties of the 20th century, this paradigm was modified. The theory of inflammation emerged. It was found that such mediators as cytokines and prostaglandins have an effect on chondrocytes [2].

The main symptoms of osteoarthritis is chronic joint pain and limitation of the function of the affected joint, which leads to the reduced quality of patients' life, decline in their mobility and, consequently, disabilities that represent serious health, social and economic problems.

Osteoarthritis is one of the most prevalent disease of the locomotor system, with morbidity differing from source to source and ranging from 2 to 15% of general population, with these numbers reaching even 15 to 25% of the Polish population [3].

Osteoarthritis is most often idiopathic, which means that their aetiology remains unclear. In young patients, especially those before 40 years of age, degenerative changes in the hip are mostly secondary, with the most frequent causes being congenital hip luxations or hip dysplasia, hip varus deformity, post-inflammatory changes, Legg-Calvé-Perthes disease or previous hip injuries. The major causes of secondary degenerative hip changes in older adults are rheumatic diseases and avascular necrosis of the femoral head [4].

It is recommended for the initial stage of osteoarthritis to start conservative treatment that should consist in combined treatment involving pharmacological treatment, physical therapy and motor rehabilitation. If the disease is progressing and the symptoms become clinical and cannot be alleviated by the conservative treatment, surgery is usually necessary.

With the dynamic development of surgical technologies and very good clinical results, surgical interventions in the treatment of osteoarthritis have become a routine method.

Furthermore, due to various causes of osteoarthritis and very good outcomes of total hip replacement, more and more young people are qualified for such surgeries. Consequently, the problem of endoprosthesis life is becoming critical.

Among the joint articulations available in the market, the indications for the use of metal on metal (MoM) and metal on polyethylene (MoP) are increasingly rare, whereas new types of articulations, with low abrasion coefficients and extended life, such as ceramic on ceramic (CoC) and Oxinium on polyethylene (S&N Verilast) [5-11] are gaining in popularity.

### Metal on metal articulation (MoM)

This joint articulation is characterized by high hardness and low abrasion and offers one of the longest life, often reaching over 40 years. Furthermore, the MoM articulations allow for using large head dimensions, leading to extended joint surfaces. However, the number of reports on the drawbacks of MoM articulations has been increasing. The critics emphasize that the metal particles released from the joint surface have a negative effect on the extraarticular tissue, leading to inflammation, metallosis and so-called pseudotumors that translate into discomfort, pain and prosthesis loosening. Release of metal particles is more intensive especially in the cases of improperly implanted prostheses. Elevated blood serum Co and Cr levels were also found in patients with MoM articulations. However, no unequivocal conclusions on the effect of this state on human body have been drawn.

### Metal on polyethylene articulation (MoP)

This is one of the longest used joint articulations in the hip endoprotheses, both in the conventional and metaphyseal systems. Polyethylene is little toxic to human body. However, due to a high abrasion coefficient, high volume of wear products is released from the steel surfaces, leading to the elevated risk of osteolysis near the prosthesis and loosening of the prosthesis. The polyethylene inserts have to be often replaced.

### Ceramic on ceramic articulation (CoC)

This technology is numbered among hard articulations. It is characterized by a low abrasion coefficient and high resistance to scratches, whereas wear products are released in smaller amounts and have low toxicity. Among the drawbacks are the risks of cracks and fractures on joint surfaces and the feeling of „squeaking hip” the patients complain about.



### OXINIUM on cross-linked polyethylene (VERILAST)

This articulation is a combination of the prosthesis head in the OXINUM technology with XLPE (cross-linked polyethylene) acetabulum obtained through the exposure of the polyethylene insert to the Gamma radiation. The system of OXINIUM heads combines benefits of other articulations (ceramic and metal) while eliminating their drawbacks. OXINIUM is an alloy of zirconium (97.5%) and niobium (2.5%). Similar to titanium, both metals are characterized by the highest level of biocompatibility. With adequate chemical processes (heat and oxidation), head surface is replaced with the ceramic surface, maintaining both properties of ceramics and metal strength. Contrary to ceramic-on-ceramic articulation (CoC), this articulation is referred as „soft”, thus reducing the risk of cracking and fractures on the prosthesis surfaces as well as the squeaking hip effect, frequently described as a complication of CoC articulation. Furthermore, this articulation is characterized by wear on the surface that is lower by 67% compared to the conventional metal on polyethylene (MoP) combinations, ensuring extended prosthesis life and inhibited release of wear products. Contrary to metal heads, this type of head does not contain nickel, thus reducing the risk of allergic reactions.

Good outcomes of treatment using hip arthroplasty and the growing number of patients who need to be treated have led to a noticeable increase in the frequency of interventions. For this reason, it is necessary to constantly monitor treatment outcomes. A series of inventories have been developed to evaluate the effects of surgeries by the analysis of the joint function and symptoms: HHS, HOOS, OHS, LISOH, AAOS Hip and Knee Questionnaire.

### Aim of the Study

The aim of the study is to evaluate the long-term effects of the cementless metaphyseal hip arthroplasty in the treatment of the hip osteoarthritis depending on the type of joint articulation.

### Material and Methods

The study analysed the patients following the surgeries due to hip osteoarthritis in the the 1st Men's Department of Trauma and Orthopaedic Surgery of the District Hospital of Trauma and Orthopaedics in Piekary Śląskie, Poland. A minimum period of 5 years of observation was assumed. Therefore, the study examined patients after surgeries in 2009-2011.

The number of study participants was 157. All patients had been operated by two senior assistants from the department who were specialists in the field of trauma and orthopaedics.

The inclusion criteria were:

- gender: men,
- patients after cementless metaphyseal hip arthroplasty with CoC or VERILAST articulation.

The exclusion criteria were age over 65 years and revision hip arthroplasty.

The patients included in the examinations were divided into two study groups:

- 69 patients with the prosthesis with CoC articulation ,
- 88 patients with the prosthesis with VERILAST articulation.

Surgery protocols were used to select patients meeting the criteria. Next, the patients' medical case records were derived from the hospital's archives in order to obtain information necessary for eventual recruitment of patients for examinations. The data obtained from medical case records contained age, body mass, body height, BMI, the side where endoprosthesis was implanted and type of degenerative changes.

Each patient qualified based on the inclusion and exclusion criteria was invited for a medical appointment to the hospital outpatient clinic, where they filled UCLA and HHS scores and had pelvis X-rayed for both hips in the AP projection. The radiological procedure focused on the diagnosis of the presence of loosening of prosthesis parts and a wear of articulation.

The data were collected in the table and then analysed statistically using Statistica 12 PL software.

Harris Hip Score (HHS) is one of the first scores, published in 1969 to evaluate the four items: pain (max. 44 points), function (max. 47 points), deformations (max. 4 points) and joint mobility (max. 5 points). Evaluation of the function and gait is based on the following elements of everyday life: stairs climbing, using public transportation, sitting, difficulties in putting on shoes and socks, necessity of walking on crutches, needing to be helped by other people and the distance the patient is able to cover. Total score is evaluated based on the sum of all four items. Maximal number of points to be scored is 100. The higher the HHS score, the lower joint dysfunction. [12]

An additional method to evaluate surgical interventions is to analyse physical activity following the surgery, which unequivocally translates into the quality of life of patients. This can be achieved by using the UCLA score to evaluate and monitor the level of physical activity across the population. The scale is composed of 10 levels of physical activity, from the whole inactivity, inability to move independently and dependency on others through amateur involvement in swimming or bicycling to regular participation in such sports as ballet, acrobatics, mountain backpacking, skiing, tennis or running.



## Results

Based on the medical case records, 157 patients were recruited, with 88 people after hip arthroplasty using Verilast articulation and 69 using CoC articulation. Mean age of patients in the Verilast group was 59 years whereas in the CoC, this was 57 years. Mean body mass, age, body height and BMI were compared. No significant statistical differences were found between groups, which means that these groups were homogeneous and comparable. The results are presented in the table below.

	OXINIUM-VERILAST n=88		CoC n=69		p value
	Mean	SD	Mean	SD	
Age	59	7	57	9	0.094
Body mass	83.1	9.21	82.5	10.03	0.688
Body height	177	5.72	178	6.31	0.167
BMI	26.6	2.51	25.9	2.89	0.113

Furthermore, the body side after operation, type of degenerative changes and the background of the avascular necrosis (AVN) of the femoral head or congenital hip luxation were also presented. A significant difference was found in the frequency of implantation of hip joint prosthesis with OXINIUM articulation in patients with avascular necrosis of the femoral head. Such endoprostheses were used in 23 patients with AVN, which accounts for 26% of the patients at the level of significance set at  $p < 0.05$  ( $p = 0.012$ )

	OXINIUM-VERILAST n=88		CoC n=69		p value
	Percentage	Number	Percentage	Number	
Primary osteoarthritis	51%	45	65%	45	0.078
AVN	26%	23	10%	7	0.012
LCC/DDH	9%	8	6%	4	0.444
Post-traumatic	10%	9	10%	7	0.989
Other	5%	4	9%	6	0.294

After the questionnaire survey, the following results were obtained for the whole study group: HHS and UCLA values increased statistically significantly in both groups of patients after hip arthroplasty. Neither HHS or UCLA results were significantly affected by the type of the articulation used, whereas improved UCLA results in the post-surgical period in the group of patients with CoC articulation were statistically significantly higher in patients with Oxinium Verilast articulation.

	OXINIUM-VERILAST n=88		CoC n=69		p value
	Mean	SD	Mean	SD	
HHS before	35.16	14.85	38.59	11.75	0.130
HHS after	87.18	8.86	88.31	7.29	0.697
p value*	<0.001		<0.001		
Improvement in HHS	52.01	15.08	49.72	12.86	0.363
UCLA before	2.78	0.84	2.71	0.77	0.878
UCLA after	5.27	1.71	5.68	1.48	0.111
p value*	<0.001		<0.001		
Improvement in UCLA	2.49	1.66	2.97	1.29	0.032

p value \* - comparison of values before and after the surgery

The tables show the HHS and UCLA results depending on the cause of osteoarthritis.

### Secondary osteoarthritis:

	OXINIUM-VERILAST n=43		CoC n=24		p value
	Mean	SD	Mean	SD	
HHS before	36.6	16.6	37.7	11.8	0.943
HHS after	89.6	6.65	88.9	7.93	0.844
p value*	<0.001		<0.001		
Improvement in HHS	53.0	15.0	51.2	13.9	0.633
UCLA before	2.84	0.87	2.58	0.65	0.336
UCLA after	5.77	1.74	6.21	1.41	0.329
p value*	<0.001		<0.001		
Improvement in UCLA	2.93	1.74	3.63	1.35	0.089

### Primary osteoarthritis:

	OXINIUM-VERILAST n=45		CoC n=45		p value
	Mean	SD	Mean	SD	
HHS before	33.8	13.0	39.1	11.8	0.025
HHS after	84.9	10.1	88.0	7.00	0.242
p value*	<0.001		<0.001		
Improvement in HHS	51.0	15.2	48.9	12.4	0.526
UCLA before	2.73	0.81	2.78	0.82	0.604
UCLA after	4.80	1.55	5.40	1.45	0.063
p value*	<0.001		<0.001		
Improvement in UCLA	2.07	1.48	2.62	1.13	0.030

p value \* - comparison of values before and after the surgery

Statistically significant improvements in the results concerning patients' functioning were obtained for both HHS and UCLA scores. Patients with primary osteoarthritis who



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were implanted endoprosthesis with Verilast articulation had worse initial results of the HHS score, whereas statistically significantly better improvement in UCLA results were found for the patients with CoC articulation.

No symptoms of loosening of the implants or wear of the articulations were observed in the control radiograms of patients.

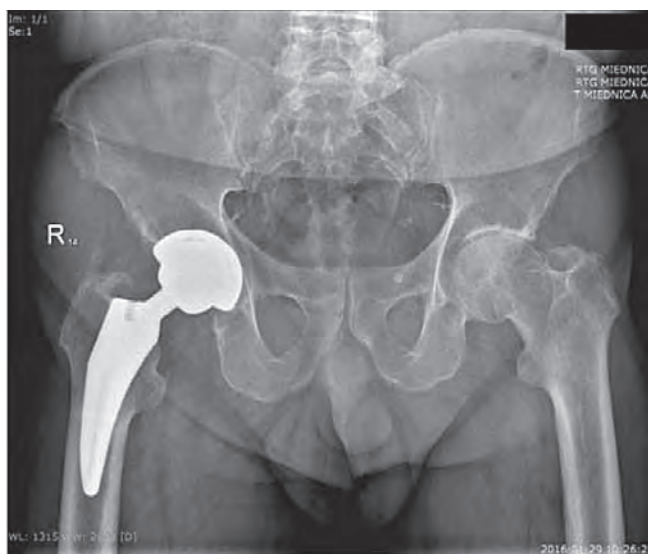


Fig. 1 – endoprosthesis with COC articulation.

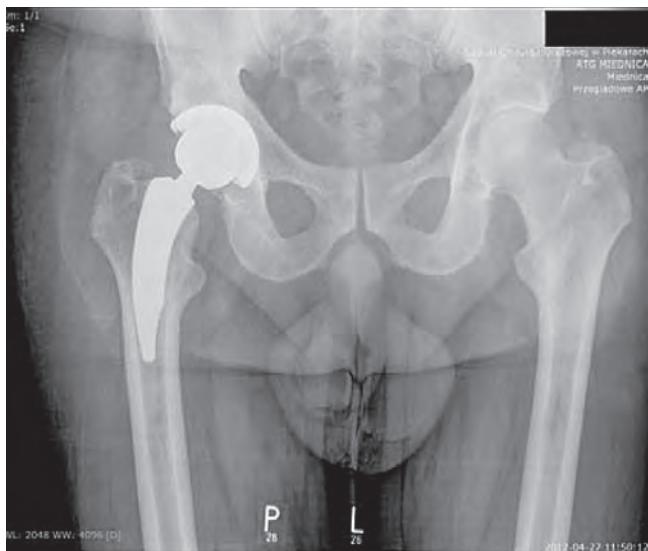


Fig. 2 – endoprosthesis with Oxinium Verilast articulation.

## Conclusion

The results of the study lead to the conclusion that hip arthroplasty in patients with hip osteoarthritis can unequivocally improve patient's quality of life and joint function regardless of the type of the joint articulation surface used in the implant.

No statistically significant differences were found to affect the HHS results depending on the articulation. The greater differences in the pre- and post-surgical results in the UCLA score may have been caused by increased activity of patients and slightly worse initial results of physical activity. The level of physical activity improved statistically significantly in both groups following the surgical intervention.

The control radiological procedures revealed a proper placement of the prostheses and good life of joint articulation.

The groups of patients examined in the study were homogeneous. Therefore, based on the results, both Verilast and ceramic articulations can be recommended for the treatment of hip osteoarthritis regardless of the aetiology of the disease.

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## PRACA ORYGINALNA

Kończyna dolna i obręcz biodrowa

# The use of reamer-irrigator-aspirator and bone-cement-coated intramedullary nails in treatment of long bones' infection after fractures fixated intramedullary

## Analiza skuteczności zastosowania rozwiertaków ssąco-płuczających i gwoździ impregnowanych cementem w leczeniu zakażeń kości długich po złamaniach zespolonych śródszpikowo

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### Abstract

**Introduction:** with the increase in the number of fractures treated operatively, the number of infectious complications, unfortunately, increases as well. In case of diagnosed infection after intramedullary fixation general "golden standard" is debridement of the infection area and then external fixation.

**Aim:** the assessment of effectiveness of the alternative method – reamer-irrigator-aspirator and intramedullary nail application in treatment long bones' infection after failure of treatment of long bone fractures with intramedullary nailing.

**Material and method:** between 2010 and 2015 in Orthopaedic Department of Professor Gruca Teaching Hospital in Otwock the debridement of intramedullary canal using reamer-irrigator-aspirator and fixation of infected long bone pseudoarthrosis using cement with antibiotic impregnated intramedullary nail was performed in 37 patients. Qualified for treatment were patients with confirmed infection and bone union disorders in long bone. The treatment was conducted in two stages. First stage consisted of operative cleaning of pseudoarthrosis area and intramedullary canal using reamer-irrigator-aspirator and then fixation with bone cement with antibiotic impregnated intramedullary nail. In the second stage the nail and cement extraction, debridement of the intramedullary canal and intramedullary nail (without cement) fixation were performed. During further treatment infection healing and bone union were assessed.

**Results:** In analyzed series of 35 cases of infectious disorders treated with described method bone union, remodeling and healing over the infection was obtained in 21 cases (60%). Healing over the infection without convinced bone union was found in 8 cases (22.9%). Non-union with clinical features of infection after the treatment was diagnosed in 6 cases (17.1%).

**Conclusions:**

1. Using reamer-irrigator-aspirator is an effective way of debridement of infected bone canal in patients in whose the infection occurred in the course of treatment using intramedullary fixation.
2. Cement-coated-nails with cement-impregnated by targeted antibiotic proved to be successful in treatment of osteomyelitis localized in bone canal after intramedullary fixation.
3. Dynamization of the nail coated by cement with antibiotic gives a possibility of self-reduction of resorption gap in place of infectionally disturbed bone union and stimulates bone union progress during the infection treatment. This element is clinically particularly important.
4. The replacement of the cement coated nail after successful healing of the infection with normal nail provides biomechanically and biologically effective treatment continuation of long bone fracture, with preserving joint mobility and limb efficiency.

**Key words:** osteomyelitis, reamer-irrigator-aspirator, long bone infection, pseudoarthrosis, intramedullary nail, bone cement

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## Streszczenie

**Wstęp:** wraz ze wzrostem liczby złamań leczonych operacyjnie zwiększa się też, niestety, liczba powikłań infekcyjnych. W przypadku rozpoznania infekcji po leczeniu śródszpikowym obowiązuje leczenie operacyjne – ogólnie przyjętym „złotym standardem” jest oczyszczenie ogniska infekcji oraz stabilizacja zewnętrzna złamania.

**Cel:** Analiza skuteczności zastosowania rozwiertaków ssąco-płuczących i gwoździ impregnowanych cementem z antybiotykiem w leczeniu infekcyjnych zaburzeń zrostu kości długich zespolonych wcześniej śródszpikowo.

**Materiał i metoda:** w okresie od 2010 do 2015 roku w Klinice Ortopedii Szpitala im. prof. A. Grucy w Otwocku zastosowano metodę oczyszczenia kanału szpikowego za pomocą rozwiertaków ssąco-płuczących i stabilizacji zakażonego stawu rzekomego kości długiej gwoździem powleczonym cementem z antybiotykiem u 37 chorych. Do leczenia zakwalifikowano chorych z potwierdzoną infekcją w obrębie kości długiej i związanymi z tym zaburzeniami zrostu. Leczenie prowadzono dwuetapowo – pierwszy etap polegał na operacyjnym oczyszczeniu stawu rzekomego i jamy szpikowej kości z zastosowaniem rozwiertaka ssąco-płuczącego oraz stabilizacji gwoździem śródszpikowym oklejonym cementem kostnym z antybiotykiem. W drugim etapie leczenia wykonywano usunięcie gwoźdź z cementem, ponowne oczyszczenie kanału szpikowego oraz stabilizację śródszpikową gwoździem bezcementowym z dynamizacją. Podczas dalszego leczenia oceniano wygojenie się infekcji oraz obecność zrostu kostnego.

**Wyniki:** W poddanych analizie 35 przypadkach infekcyjnych zaburzeń zrostu leczonych opisywaną metodą zrost kostny z przebudową i wygojeniem się infekcji uzyskano w 21 przypadkach (60%), zaś cechy wygojenia się infekcji bez uzyskanego zrostu w 8 przypadkach (22,9%). Brak zrostu z klinicznymi cechami nawrotu zakażenia po zastosowanym leczeniu stwierdzono w 6 przypadkach (17,1%).

### Wnioski:

1. Zastosowanie rozwiertaków ssąco-płuczących jest skutecznym sposobem oczyszczenia zakażonej jamy szpikowej po zespoleniu śródszpikowym kości długich.
2. Gwoździe oklejone cementem z antybiotykiem celowanym wykazały istotny element powodzenia w leczeniu zapalenia kości w łożu zespolenia śródszpikowego.
3. Dynamizacja gwoźdź oklejonego cementem z antybiotykiem umożliwia samoredukcję szpary resorpcyjnej w miejscu zapalnie zaburzonego zrostu i stymuluje postęp zrostu kostnego w trakcie leczenia zapalenia. Element ten jest szczególnie istotny klinicznie.
4. Wymiana gwoźdź z cementem po wyleczeniu zapalenia, na klasyczny gwoźdź śródszpikowy stanowi skuteczną biomechanicznie i biologicznie kontynuację leczenia złamania kości długiej, z zachowaniem ruchów stawach i bez upośledzenia sprawności kończyny.

**Słowa kluczowe:** zapalenie kości, rozwiertak ssąco-płuczący, infekcja kości długiej, staw rzekomy, gwoźdź śródszpikowy, cement kostny

## Introduction

With the increase in the number of fractures treated operatively, the number of infectious complications, unfortunately, increases as well. The current treatment standard for long bone fractures of lower limbs is stabilisation with intramedullary inter-locking nail and early mobilisation of the patient. In case of postfracture bone non-union the possibility of an infection should always be taken into consideration. If infection is confirmed, the standard procedure is the extraction of fixation material, debridement of infected area and immobilisation with plaster or external fixation. Extraction of infected fixation material is necessary due to the presence of biofilm – a bacterial spore formation allowing them to survive in unfavourable environment (for example, in the presence of antibiotics). Moreover, the biofilm structure itself prevents successful antibiotic penetration [1].

Treatment of chronic infections of motor organs, regardless whether these are periprosthetic or postfracture infections, is difficult and should always be preceded with planned diagnostics and eradication of internal inflammatory processes according to guidelines of Philadelphia Consensus [2]. What must be ruled out are any acute or chronic urinary infections, oral infections (including periapical changes invisible in standard oral examination and possible to diagnose only with panoramic radiograph and dental consultation) and in case of women also pelvic infections. Failure to perform any of these steps may result in prolonged spreading of bacteria from infection areas and failure of orthopaedic treatment.

External fixation is uncomfortable for the patient and is prone to a number of possible complications (plaster-caused damages). Treatment with plaster cast increases the risk of venous thromboembolic disease, causes muscle damage in fixated limb and limits mobility of fixated joints. Moreover, it is often impossible to maintain proper fixation of bone fragments, particularly of bodies of long bones, with plaster cast. Using external fixation structure, apart from it being a long-term treatment and uncomfortable for the patient, poses a risk of periimplantitis. Dynamisation of such fixation also requires the use of special dynamic splints which are not widely available.

A possible solution for the above-mentioned problems may be the treatment method used in our facility where long bone infections after fractures fixated intramedullary were treated with the use of reamer-irrigator-aspirator (RIA) (Fig. 1) and bone-cement-coated intramedullary nails (Fig. 2). The RIA system with its simultaneous irrigation and aspiration of bone canal allows for its complete full-length cleaning [3-6]. After this procedure bone canal is ready for implantation of dynamically locked intramedullary nail coated with cement and targeted antibiotic.



Fig. 1. RIA – reamer-irrigator-aspirator.



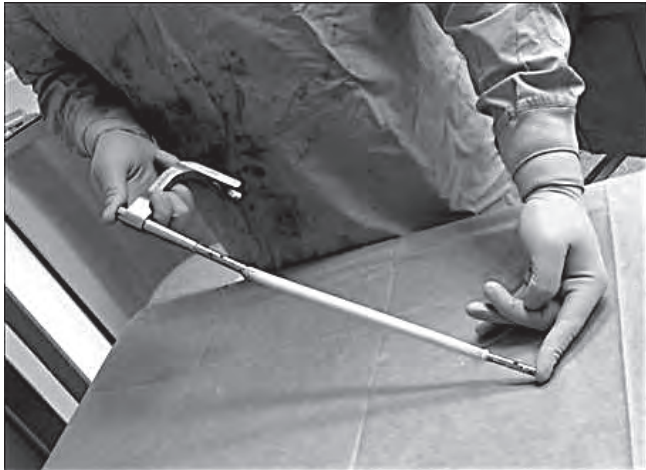


Fig. 2. Bone-cement-coated intramedullary nail with targeted antibiotics. Holes for the screws are not coated with cement.

## The aim of the study

The assessment of effectiveness of the alternative method – reamer-irrigator-aspirator and intramedullary nail application in treatment of long bones' infection after the failure of treatment of long bone fractures with intramedullary nailing.

## Materials and methods

Between 2010 and 2015 the CPME Orthopaedics Department in Otwock has performed 40 debridement procedures of intramedullary canal using reamer-irrigator-aspirator and fixation of infected long bone pseudoarthrosis using cement with antibiotic impregnated intramedullary nail in 37 patients (in 3 patients the treatment was applied to two long bones). A total of 73 operative procedures were performed (implantation, nail replacement, nail extraction), including 41 cement coated nail implantations (with clindamycin (standard) or vancomycin if culture results were positive for methicillin-resistant *Staphylococcus* prior to procedure) using reamer-irrigator-aspirator RIA. Performed procedures included 10 implantations of cement impregnated intramedullary nail in femoral bone and 28 implantations in tibial bone (in 2 patients both tibial and femoral bones were fixated, in one of them, due to infection recurrence, bone canal debridement with RIA with cement and antibiotic impregnated bone nail fixation was performed twice; in second patient both tibial bones were treated with this method). Moreover, with the use of reamer-irrigator-aspirator RIA and bone cement with antibiotic impregnated intramedullary nail, talocrural joint arthrodesis was performed in 1 patient and knee arthrodesis in another patient (as fixation of perijoint fractures).

Treatment was applied to a total of 37 patients – 10 women and 27 men. Age of patients was between 19 and 82 years old (34 years old on average). Among all cases, 18 patients (48.6%) had open fractures with multiple organ injuries, 10 patients (27%) – isolated open limb fractures, 4 patients (10.8%) had closed fractures with multiple organ injuries, 4 patients (10.8%) had developed infectious complications in the course of closed fracture treatment and 1 patient (2.7%) had developed an infection in the course of orthopaedic treatment (knee osteotomy and arthrodesis). All patients were qualified for the assessed procedure after failure of previously applied intramedullary treatment and after clinically diagnosed infection of pseudoarthrosis (with or without prior bacteriological confirmation).

During the qualification process elevated ESR and CRP levels were confirmed in 35 out of 37 patients (94.6%). In 31 cases (out of 40 inflammatory bone union disorders, 77.5%) typical skin symptoms were observed in form of local discolorations and/or active fistulae with purulent discharge.

During procedures, biological material for bacteriological analysis was always obtained. In 30 cases (75%) results confirmed pathogenic bacteria. The most common cause of bone canal infection and bone union disorders was methicillin-sensitive *Staphylococcus aureus* (MSSA) – it was confirmed in 20 cases (50%), 6 of them (15%) also had a coexisting infection with other disease pathogens. In 4 cases (10%) *Pseudomonas aeruginosa* infection was confirmed, and in 2 cases (5%) an *Escherichia coli* infection. Single cases of *Prevotella melaninogenica*, *Bacillus* spp and *Klebsiella pneumoniae* infections were also confirmed. In 2 cases (5%) the cause of the infection was methicillin-resistant *Staphylococcus epidermidis* (MRSE) and in 1 case (2.5%) it was methicillin-resistant *Staphylococcus aureus* (MRSA). In 6 cases (15%) no disease pathogens were isolated from biological material. Their diagnosis was, therefore, based on clinical image and elevated ESR and CRP levels.

In the perioperative and early postoperative period antibiotic therapy was used according to recommendations of Hospital Infection Committee (following guidelines of National Medicines Institute), which recommends the use of second-generation cephalosporin and aminoglycoside except in cases where disease pathogens were confirmed in earlier treatment stages [7]. In these cases prior antibiotic therapy targeted found pathogens unless standard recommended medicines had these pathogens already included in their spectrum. After obtaining specific cultures, antibiotic therapy was applied according to antibiogram. After the procedure patients were hospitalised for approximately 11 days. After discharge, outpatient monitoring and pharmacological treatment was applied. First outpatient follow-up appointment was scheduled after 4-6 weeks. CRP and ESR tests and X-ray imaging were performed and patient's clinical condition was assessed.

In the period between 6 weeks and 16 months since primary bone canal debridement and cement impregnated nail implantation patients were qualified for the second treatment stage – extraction of cement coated nail, new bone canal debridement using conventional methods (long curettes, typical bone canal drilling, pulse lavage) and intramedullary fixation with cementless nail. Among all 40 primary implantations of cement coated nail, cement intramedullary nail was replaced with a cementless nail in 33 cases, which accounts for 82.5% of bone union disorders (in 1 patient cement coated nail was replaced with another cement coated nail due to prolonged infection). In 4 cases (10%), due to successful bone union and healing of infection, cement coated nail was extracted without any further nail implantation. In 1 patient, due to prolonged infection, the cement coated nail was extracted without further intramedullary fixation. 2 patients failed to appear for a follow-up appointment and nail removal.

Bone union was assessed on the basis of 2 projection X-rays in vertical position. Normalised CRP with lack of clinical local infection features were considered a confirmation of healed infection.

32 patients with 35 infectious bone union disorders came for at least 3 follow-up appointments (which accounts for 87.5% of all treated infectious bone union disorders). In cases of recurring infection after replacement of cement coated nail with cementless nail, extraction of fixation material was performed and further treatment with a different method was introduced.

## Results

Final assessment during observation period of 6 to 36 months after procedure was conducted in 32 cases with 35 infectious bone union disorders. Complete bone union with remodeling and healing of infection was achieved in 21 cases (60%), lack of complete union with healing of infection (with progressing union during observation) in 8 cases (22.9%), bone non-union with clinical features of infection recurrence in 6 cases (17.1%, where in 1 patient active infection is present in one of two treated limbs).

Currently 14 patients are undergoing further treatment and observation. Due to considerable difficulties in treatment of long bone pseudoarthrosis and the necessary long recovery period, we expect it is possible to achieve bone union in patients with healed infection.

## Examples:

### Example 1.



Fig. 3. 24 y.o. patient – open fracture of left tibia (IIIA Gustilo-Anderson classification). Signs of infection around fracture site. Primary treated with intramedullary nailing. Incorrect distal stabilization of the nail – lack of rotation stability.

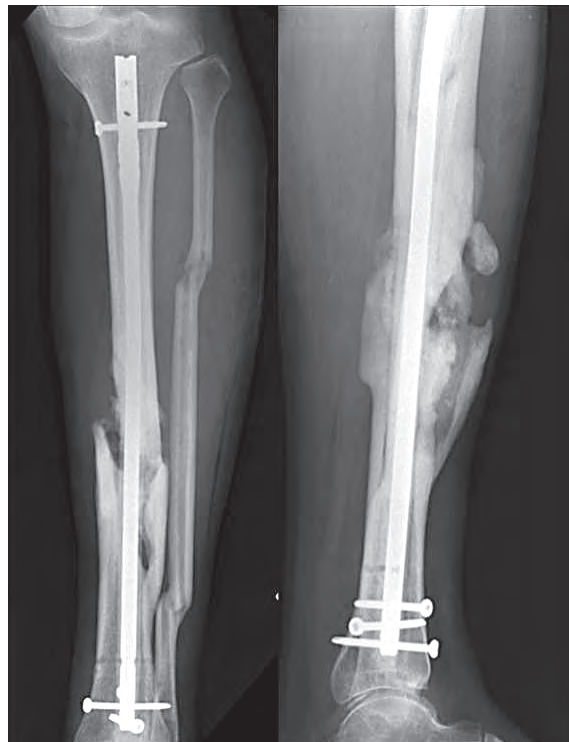


Fig. 4. Treatment – IM nail removal, debridement of intramedullary canal using reamer-irrigator-aspirator, fixation of infected bone pseudoarthrosis using cement with vancomycin impregnated intramedullary nail. Primary proximal nail dynamization.

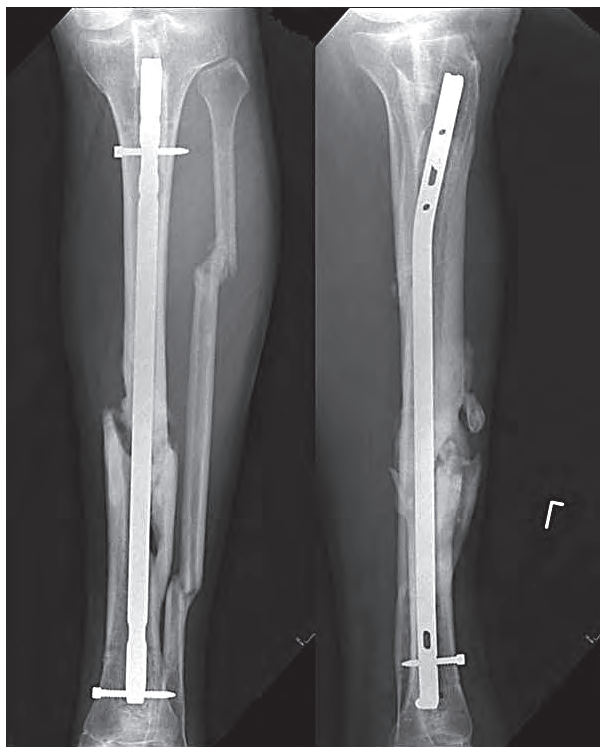


Fig. 5. After 8 weeks second stage: nail and cement extraction, debridement of the intramedullary canal, intramedullary nail (without cement) fixation with proximal dynamization.



Fig. 6. After 2 years – no symptoms of infection and bone union.

Example 2.

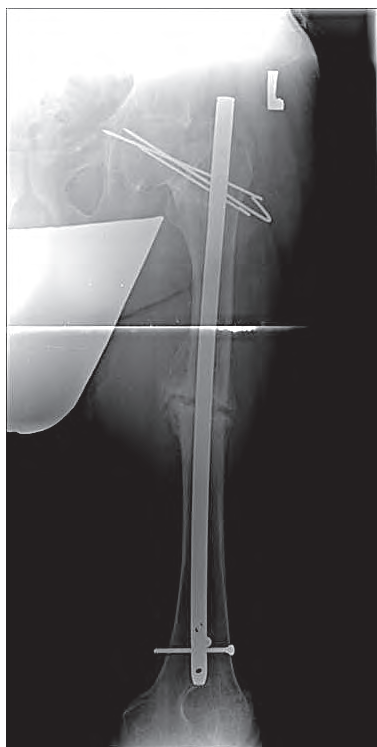


Fig. 7. 30 y.o. patient –multiple femur injury, fracture of the shaft and neck. Infected pseudoarthrosis of the femur shaft. Incorrect proximal stabilization.



Fig. 8. Treatment – nail extraction, debridement of the intramedullary canal and pseudoarthrosis, fixation with cement impregnated intramedullary nail, after 4 weeks nail replacement



Fig. 9. After 3 years – bone union and remodeling.

## Discussion

Achieving bone union after long bone infections in fractures fixated with intramedullary nail is extremely difficult. The core of the treatment is the extraction of metal and debridement of infected and dead tissues. The solution based on complete debridement of bone canal, convinced dynamic internal stabilisation with simultaneous local (and broad) antibiotic therapy is less strenuous for the patient and may serve as an alternative for commonly used treatment methods [8]. The use of RIA may potentially lead to heavy bleeding and coronary episodes [9]. During the trial the authors have not observed such complications.

Based on the trial conducted so far, we can declare that complete debridement of bone canal with reamer-irrigator-aspirator is the key in eradication of infected areas in bone canal and local antibiotic therapy with the use of bone cement is an effective method of bone infection treatment due to achieved high local concentration of antibiotic. Combination of local treatment with broad antibiotic therapy allows for optimisation of treatment of infected pseudoarthrosis.

There are studies indicating a key role of bone canal reaming in the process of obtaining bone union and for this reason it is safe to assume that complete debridement of infected area in bone canal will not hinder the formation of bone union. Stable and necessarily dynamic intramedullary fixation allows for early mobilization of the patient (usually on the second day after procedure) and postoperative rehabilitation, it prevents muscle damage and deficiencies in joint mobility.

In future studies authors plan to assess the quality of life of patients who underwent the described treatment procedure because this parameter helps illustrate how the assessment of treatment results made by the operator correlates with patient satisfaction due to used treatment method.

## Conclusions

1. Using reamer-irrigator-aspirator is an effective way of debridement of infected bone canal in patients in whose the infection occurred in the course of treatment using intramedullary fixation.
2. Cement-coated-nails with cement impregnated by targeted antibiotic proved to be successful in treatment of osteomyelitis localized in bone canal after intramedullary fixation.
3. Dynamization of the nail coated by cement with antibiotic gives a possibility of self-reduction of resorption gap in place of infectionally disturbed bone union and stimulates bone union progress during the infection treatment. This element is clinically particularly important.

4. The replacement of the cement coated nail after successful healing of the infection with standard nail provides biomechanically and biologically effective treatment continuation of long bone fracture, with preserving joint mobility and limb efficiency.

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## OPIS PRZYPADKU

Kończyna dolna i obręcz biodrowa

# Knee arthroplasty in a patient with severe haemophilia A with inhibitors – a case report

## Endoprotezoplastyka stawu kolanowego u chorego z hemofilią A powikłaną inhibitorem – opis przypadku

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### Abstract

Haemophilia A (HA) is a genetic disease characterized by deficiency or defect of VIII plasma factor (fVIII). Standard treatment using purified plasma-derived or recombinant fVIII concentrates may develop inhibitory antibodies against fVIII. Patients with severe disease suffer from frequent bleedings into joints which causes synovial proliferation, chronic synovitis, as well as cartilage and bone destruction. Severe haemophilic knee arthropathy is treated surgically by total knee arthroplasty. The presence of inhibitor makes therapy more difficult because of the potential risk for uncontrollable bleeding and wound healing problems. We described a case of a 36-year-old man with severe HA with inhibitors undergoing total left knee arthroplasty for haemophilic arthropathy. In the postoperative period at hospital where patient spend one and half month, combined treatment with rfVIIa, the anti-inhibitor coagulant complex, Exacyl and Cyclonamine was used. The only complication that occurred postoperatively was haemorrhage which was due to left leg overloading. According to this experience, total knee arthroplasty is an effective method to treat haemophilic arthropathy of the knee because it can decrease pain, haemorrhage episodes, treatment costs, and increase joint function and the quality of life.

**Key words:** haemophilia A, knee arthroplasty, haemophilic arthropathy

### Streszczenie

Hemofilia jest genetycznie uwarunkowaną skazą krwotoczną spowodowana niedoborem czynnika krzepnięcia VIII. Standardowe leczenie substytucyjne bywa powikłane wytworzeniem alloprzeciwciał przeciwko czynnikowi VIII (inhibitor). U pacjentów chorujących na tą chorobą często dochodzi do nawracających krwawień do stawów, co w konsekwencji prowadzi do artropatii hemofilowej spowodowanej przerostem błony maziowej oraz toksycznym wpływem składników krwi na chrząstkę stawową. Leczeniem z wyboru zaawansowanej artropatii hemofilowej jest alloplastyka stawów. Obecność inhibitora znacznie utrudnia leczenie operacyjne chorych z tym schorzeniem, ze względu na ryzyko niekontrolowanych krwawień i zaburzeń w gojeniu rany pooperacyjnej. W pracy przedstawiliśmy wynik leczenia 36-letniego chorego z artropatią stawu kolanowego w przebiegu hemofilii powikłanej inhibitorem, u którego wykonaliśmy operację endoprotezoplastyki stawu kolanowego. Zbyt wczesne obciążenie operowanej kończyny, w okresie pooperacyjnym, doprowadziło u chorego do intensywnego krwawienia z rany operacyjnej oraz zaburzeń w jej gojeniu co znacznie wydłużyło okres leczenia. Ostateczny dobry wynik leczenia pozwala na stwierdzenie, że endoprotezoplastyka stawu kolanowego jest skuteczną metodą w leczeniu artropatii stawu kolanowego u chorych z hemofilią powikłaną inhibitorem.

**Słowa kluczowe:** hemofilia, endoprotezoplastyka stawu kolanowego, artropatia hemofilowa

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## Introduction

Haemophilia A (HA) is an X-chromosome-linked disorder caused by deficient or defective plasma factor VIII (fVIII). In patients with HA, insufficient coagulant activity results in spontaneous bleeding into joints, muscles and internal organs, as well as trauma-induced bleeding after injury and surgery. Patients with severe disease (fVIII levels below 1% of the normal level) suffer from frequent bleedings into joints [1]. Joint bleeding causes synovial proliferation, chronic synovitis, as well as cartilage and bone destruction. These pathological changes lead to haemophilic arthropathy which is characterized by pain, stiffness, and deformity [2].

HA is treated either with purified plasma-derived or recombinant fVIII concentrates. However, as a consequence, inhibitory antibodies against fVIII (hereafter termed inhibitors) may develop. As these inhibitors bind fVIII, and thus preclude its haemostatic activity, they represent one of the most significant complications of HA treatment. Inhibitors are detected in up to 36% of patients with severe HA [3]. Orthopaedic complications are more frequent and severe in HA patients with inhibitors compared to those without inhibitor [4]. HA with inhibitors requires treatment with bypassing agents, such as recombinant activated factor VII (rfVIIa) or activated prothrombin complex concentrate (APCC) [5, 6].

Severe haemophilic knee arthropathy is treated surgically by total knee arthroplasty. This treatment leads to pain relief and functional improvement [7, 8, 9]. However, until recently, elective surgical procedures were avoided in patients with inhibitors – because of the potential risk for uncontrollable bleeding [10] and wound healing problems [11]. Here we report the case of a HA patient with inhibitors undergoing total knee arthroplasty for haemophilic arthropathy.

## Case report

A 36-year-old Caucasian man with HA with inhibitors was admitted to the Clinic of Orthopaedics, for the purpose of total knee arthroplasty. The patient's medical history included severe HA (fVIII < 1% of the normal level) diagnosed in early childhood, haemophilic arthropathy, and untreated infection with the hepatitis C virus (HCV). The patient suffered from frequent intra-articular bleedings into the following target joints: both knees, both elbows, both ankles, and the left shoulder.

The inhibitor was first detected when the patient was 20 years old, with an inhibitor titre of  $\geq 4000$  BU. The highest inhibitor titre in the patient's past medical history exceeded  $\geq 7000$  BU. Initially, the patient was treated with plasma-derived fVIII concentrate. After inhibitor development, higher and more frequent doses of fVIII were applied with addi-

tion of factor IX, but this treatment did not control bleedings. Seven years prior to the total knee arthroplasty, rfVIIa (NovoSeven, Novo Nordisk Inc., Plainsboro, New Jersey, USA) treatment had been initiated and continued due to beneficial effects. Four years prior to total knee arthroplasty, the patient underwent a trauma laparotomy followed by two reoperations due to trauma-induced, chronic intraperitoneal haemorrhage. In the postoperative period, a combined treatment with rfVIIa (NovoSeven) and the anti-inhibitor coagulant complex (factor eight inhibitor bypass activity, FEIBA) was used.

At the time of admission to the Orthopaedics Clinic, the patient presented functional disability due to haemophilic arthropathy, but was independent in activities of daily living. He required opioid therapy for severe pain. The physical examination the day before the surgery did not reveal any significant clinical findings. The orthopaedic examination of the left knee joint showed pain during exertion and at rest, limitation of flexion to 10 degrees, but no extension limitation, and no knee effusion (Fig. 1). The inhibitor titre level was 269 BU.

The patient was administered 8 mg of NovoSeven directly before the surgery. The total left knee arthroplasty was performed using Stryker Triathlon implant (Stryker, Kalamazoo, MI, USA). During the surgery, no excessive bleeding was observed and perioperative haemostasis was achieved.

Postoperative haematological treatment included 8 mg of NovoSeven every 2 h on day 1 after the surgery, every 3 h on day 3 after the surgery, and every 4 h from day 3 to day 7 after the surgery. De-escalation of the treatment started from day 8 due to the lack of bleeding from the postoperative wound (8 mg of NovoSeven was administered every 6 h). In addition, Exacyl (0.5 g, three times per day) and Cyclonamine (0.5 g, four times per day) were administered intravenously. In total, 448 mg of NovoSeven was used during the first ten days following the surgery.

On day 11, the treatment was changed from NovoSeven to FEIBA (4000 U every 8 h). This change was due to the temporal unavailability of NovoSeven. Exacyl treatment was stopped. On the same day, bleeding from the postoperative wound occurred, which continued during the following 10 days. As a result of the bleeding, the sutures were not removed and NovoSeven was reintroduced instead of FEIBA on day 20 after the surgery. The initial dose of NovoSeven was 8 mg every 6 h, which was increased to 8 mg every 3 h, and then combined with Exacyl and Cyclonamine (3 x 2 amp). After 5 days, the bleeding decreased and the NovoSeven dose was reduced to 8 mg every 6 h. The patient was in overall good condition, and after another 2 days, the NovoSeven dose was further reduced to 8 mg every 8 h. Thirty days after the surgery, the bleeding stopped, haemostasis was achieved, and the NovoSeven dose was reduced to 8 mg per day. Three days later, the patient overloaded the left leg.





As a result, haemorrhage-induced necrosis of the quadriceps femoris muscle occurred, which was proven by ultrasound examination. NovoSeven treatment was reintroduced at a full dosage of 8 mg every 2 h for two days, then reduced to 8 mg every 8 h for another two days. The patient remained under observation for the following 3 days and was then discharged. One and a half months after the surgery, the inhibitor titre was 228 BU. Seven months after the surgery, flexion of the left knee joint increased to 35–40 degrees.

During the first year after the surgery, the patient did not experience pain in the left knee joint. The number of bleedings and, consequently, the usage of bypassing agents decreased compared to the year before the surgery (NovoSeven: 205 mg vs. 90 mg; FEIBA: 50,000 U vs. 16,000 U).

## Discussion

Here, we described a case of a 36-year-old man with severe HA with inhibitors undergoing total left knee arthroplasty for haemophilic arthropathy. The patient required bypassing medication (rfVIIa/FEIBA) prior to and after the surgery. After the surgery, the patient experienced pain reduction and range of motion improvement. The lack of pain and good general condition caused too rapid mobilisation of the patient who did not adhere to physician's instructions. The only complication that occurred postoperatively was haemorrhage which was due to left leg overloading. The desire to restore motion in this patients must be tempered by the need for rest to allow wound healing [12]. In contrast with the traditional paradigm of mobilizing patients as quickly as possible after knee arthroplasty early mobilization in patients with haemophilia and inhibitor is not recommended.

According to a previous report on 12 patients with haemophilic arthropathy, results of total knee arthroplasty were good or excellent in 94% of cases. The greatest improvement was in pain relief, whereas 6 patients experienced recurrent haemarthrosis [13]. Beneficial effects of total knee arthroplasty have been also described in haemophilic patients with stiff knees. Although the surgery was successful in patients with stiff knees, their clinical outcome was inferior to those with a less limited range of motion [14]. Recently, the safety and effectiveness was also shown for simultaneous bilateral total knee arthroplasty [15]. Moreover, a retrospective study on 74 haemophilic arthropathy patients undergoing total knee arthroplasty demonstrated good prosthetic survival at 5 and 10 years, with excellent pain relief [16]. Studies in haemophilic patients have demonstrated that their quality of life (QoL) is reduced comparing to healthy controls, especially in patients with severe disease [17]. Interestingly, in HA patients with inhibitors, QoL is dependent on the orthopaedic status, whereas other aspects do not have strong impact on

patients' wellbeing [18]. This suggests that special attention should be paid to the management of orthopaedic complications in these patients. Our case shows that after total knee arthroplasty the patient benefited from increased QoL. During the first year after the surgery, pain disappeared and the number of bleedings at the operated joint was reduced. The patient required less intensive bypassing treatment and, as a result, his hospital visits were less frequent.

In this case report, we showed that an individual suffering from severe HA with inhibitors also benefited from this kind of surgery. Similar to our findings, an exploratory paper based on literature modelling showed that knee surgery in HA patients with inhibitors reduced the mean number of annual bleeding episodes at the affected joint from 9.13 to 1.64. As a consequence of the reduction in bleeding episode number, treatment costs will decrease [19]. Thus, the surgery itself is a tool that offsets the costs of medical intervention. In our case, during the first year after the surgery, the patient used 2.3 times less NovoSeven and 3.1 times less FEIBA than during the preceding year. This important economical aspect of total knee arthroplasty should also be taken into consideration when managing HA patients.

In summary, this case provides further evidence for the safety and efficacy of total knee arthroplasty in severe HA with inhibitors. This surgery leads to an improved QoL in patients with HA with inhibitors due to a reduction in the number of haemorrhage episodes, as well as providing pain relief. Total knee arthroplasty also offers an economic advantage by reducing the consumption of bypassing agents.

Declaration of interest: The authors declare that they have no interests that might be perceived as posing a conflict or bias.

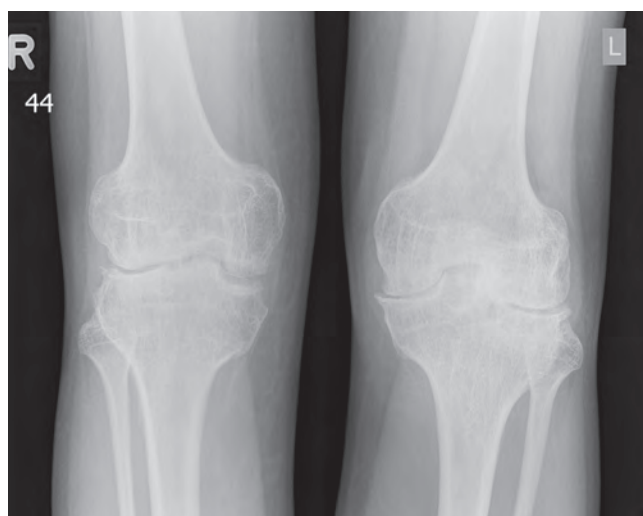


Fig. 1. Preoperative radiographs of both knee joints in the patient with haemophilia A, showing the severe arthropathy of the left knee.

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