

Edward GOLEC^{1,2,3}
Sebastian NOWAK¹
Aneta BAC²
Joanna GOLEC^{2,4}
Elżbieta SZCZYGIEL⁴
Dorota CZECHOWSKA²
Renata WOŹNIACKA⁵

Treatment results and assessment quality of life in patients after revision total hip replacement because of infection

Wyniki leczenia oraz ocena jakości życia chorych po całkowitej rewizyjnej alloplastyce stawu biodrowego z powodu zakażenia

¹Traumatic Surgery and Orthopaedic Clinic, 5th Military Clinical Hospital with Policlinic Independent Public Health Care, Cracow, Poland
Head: Prof. Edward Golec

²Rehabilitation in Orthopaedics, Department of Clinical Rehabilitation, Faculty of Rehabilitation, University School of Physical Education, Cracow, Poland
Head: Prof. Edward Golec

³The Basic Physiotherapy, Faculty of Physiotherapy, High School of Administration, Bielsko-Biala, Poland
Head: Prof. Edward Golec

⁴Andrzej Frycz Modrzewski Cracow University, Faculty of Physiotherapy Cracow, Poland
Head: Prof. Bogusław Frańczuk

⁵Department of Physiotherapy, Faculty of Rehabilitation, University School of Physical Education, Cracow, Poland
Head: Prof. Marek Pieniążek

Słowa kluczowe:
alloplastyka rewizyjna stawu biodrowego
zakażenie
jakość życia

Key words:
revision total hip replacement
infection
quality of life

Corresponding author:
Edward Golec
Rehabilitation in Orthopaedics,
Department of Clinical Rehabilitation,
Faculty of Rehabilitation,
University School of Physical Education,
al. Jana Pawła II 78, 31-571 Cracow, Poland
phone: +48602-33-58-68
e-mail: bgolec@poczta.onet.pl

The research included 14 patients with infections of a total hip replacement (THR). The reason of revision total hip replacement (rTHR) was the septic loosening of hip endoprosthesis confirmed with the clinical study, the radiological image, the scintigraphic and bacteriological examination. All controlled patients had a quality of life evaluation according to PAIS criterions. In the 7 patients after earlier implantation endoprosthesis Spacer was succeeded with no signs of return to the infections. However, in the next 7 people we had not enhanced the meaning remission of the infection and situation required removing of the implants. The long-lasting infection of the bone after total hip replacement, reduced quality of life of the patients. Applying of the temporary antibiotic-loaded bone cement spacer endoprosthesis in septicly complicated total hip replacement is reasonable and should be used in the early period.'

Introduction

One of the complications of total hip replacement (THR) is the septic loosening of the implant being both early as well as long term complication [1,2]. This is a very difficult, increasing and chronic health problem in general due to continuously magnifying population of patients after THR. It is constantly discussed clinical although significant psychosocial problem requiring the multidirectional and interdisciplinary efforts. That situation determined several operative procedures which is certainly using the antibiotic bone cement in the primal and revision alloplastics and antibiotic-loaded bone cement spacer endoprosthesis SPACER in meantime [2-4].

It makes the specific kind of antibacterial prevention about and post-operatively. In case of confirmed implant infections, patients with the septic complications are initially recommended with the wide-spectral antibiotic therapy and

Badaniami objęto 14 chorych z zapalnymi powikłaniami endoprotezoplastyki całkowitej stawu biodrowego (THR). Powodem endoprotezoplastyki rewizyjnej stawu biodrowego (rTHR) było septyczne obluzowanie endoprotezy potwierdzone badaniem klinicznym, obrazem radiologicznym, badaniem scyntygraficznym i bakteriologicznym. U wszystkich chorych oceniono także jakość ich życia w oparciu o kryteria PAIS. U 7 chorych po wcześniejszej implantacji endoprotezy typu Spacer, nie odnotowano nawrotu procesu zapalnego. U 7 jednak stwierdzono jego nasilenie, co wymagało usunięcia implantów. Stwierdzono także, że długotrwałe zakażenie kości po endoprotezoplastyce całkowitej stawu biodrowego niekorzystnie wpływa na jakość życia chorych. Zastosowanie endoprotezy tymczasowej typu Spacer u chorych z septycznymi powikłaniami endoprotezoplastyki całkowitej stawu biodrowego jest postępowaniem uzasadnionym, które należy stosować we wczesnym jego okresie.

then, after the identification of the microorganism – with the aimed antibiotic therapy [3,5,6]. The temporary removal of the implant and making the revision alloplastics after getting the remission in the inflammatory process is connected with numerous problems.

This is certainly the possibility of having an effect on the bacteriological factor only via antibiotic therapy and in long-term, it also threatening the progressing decline of the destroyed bone tissue with both the inflammatory process and its demineralization resulting from the lack of loading bones, and these are finally the contractures and a cicatrization of surrounding tissues - factors, that in the future are making hard to make revision total hip replacement (rTHR). These problems have the different meaning while implanting into the infected environment the SPACER [7-12]. Not only it enables the direct penetration of the antibiotic into the environment inflammably changed but also allows for making motions with

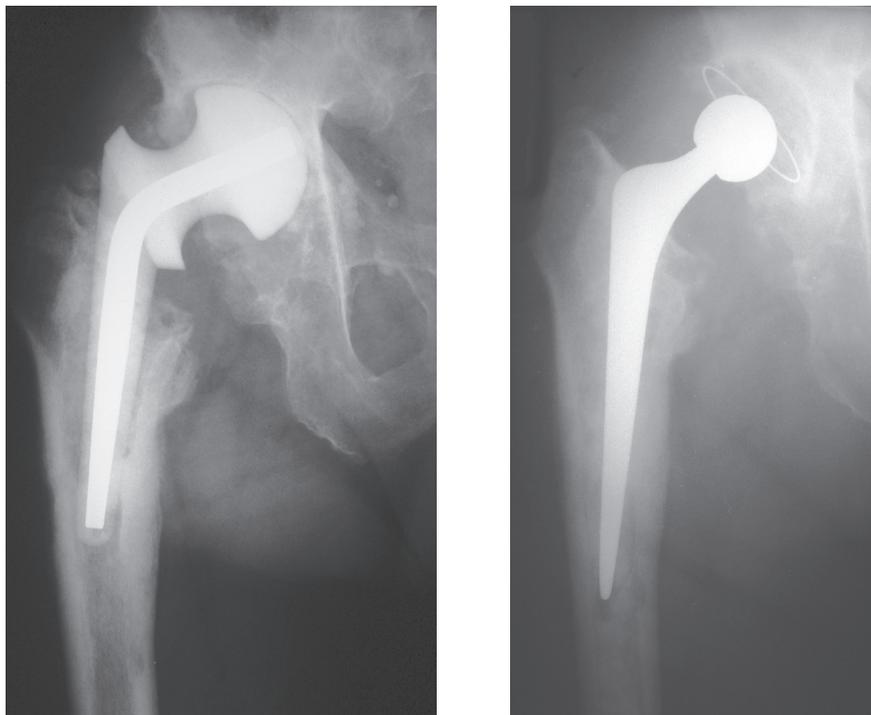


Figure 1
a) SPACER type hip implant, b) revision endoprosthesis Exeter type reimplanted after SPACER use.

operated joint and prevents its contractures and cicatrization. The main purpose of that work was the evaluation of rTHR results after earlier SPACER implantation and how is changed psychosocial adjustment ability to life.

Methods

Setting and participants

Clinical material from 2002 to 2010 year includes fourteen patients with infections of a THR. The patients examined were from 69 to 74 years old (the average age was 71), including eight female (57,1%) and six male (42,9%) of the global number of people examined.

All patients of study group gave their informed consent to the research. The main reason of rTHR was the septic loosening of hip endoprosthesis confirmed with the clinical study, the radiological

image, as well as the scintigraphic and bacteriological examination. Twelve patients including eight female and four male were treated with the primal hip alloplastics executed outside the authors' clinic. The remaining two male patients determines the own material. The observation period was from 7-36 months, on average 18 months, it starting from the day of SPACER removing.

Measures

Initially, the undertaken procedure was based on removing the original implant, removing the bone cement and accurate lavage irrigation of bone stock. Then SPACER was inserted into the diaphyseal canal of the femur. In all discussed cases, SPACER was held for a period from 4 to 6 months After it SPACER was removed and rTHR was performed.

The control examination was carried out in operated patients between 7 and 36 month – the average time was 18 months. All controlled patients had a quality of life evaluation according to PAIS criteria [13,14]. Moreover clinical, radiological and scintigraphic examination. However, the bacteriological examination was also executed in patients with the active inflammable process manifested in the presence of the inflammable fistulas. Quality of life assessment using The Psychosocial Adjustment to Illness Scale (PAIS) criteria was based on rating seven primary domains of adjustment: health-care orientation, vocation, domestic environment, sexual relationships, extended family relationships, social environment, and psychological stress. The scale consists of 46 items, each one is rated on four-point of adjustment, higher scores on the PAIS indicate poorer adjustment, total maximum score is 138 points. The clinical examination was based on the evaluation of the walk function, the measurement of limbs length in absolute dimension, the range of the chattel of the operated joint and the evaluation of the presence of inflammable fistulas (Table I).

The radiological examination was made in the typical AP projection comparing its result with earlier roentgenograms. The scintigraphy was made using a method of marked leucocytes and then comparing it with earlier results. The bacteriological examination was made in patients with active inflammable fistulas.

Statistical analyses

All statistical analyses were performed using SPSS version 14,0 Pl. Chi-squared analyses for categorical variables was used. The statistical significance between groups was confirmed at the P-value <0,05.

Results

In the seven operated patients, including six female (42.9%) and one male (7.1%), the rTHR procedure after earlier implantation of SPACER was succeeded with no signs of return to the inflammatory process. In all above cases, the septic complication was diagnosed in the early period after the primary THR. However, in the next seven people including two female (14.2%) and five male (35.8%) despite applying the SPACER, we had

Table I
Characteristic of patient samples

Parameters	Total	Men	Women	No success of alloplastic	Success of alloplastic
Number of patients n (hips) [%]	14 (100.0)	6 (42.9)	8 (57.1)	7 (50.0)	7 (50.0)
Age (years) X±SD (min-max)	71.5±1.7 (69-74)	71.2±1.2 (70-73)	71.8±2.0 (69-74)	71.1±1.5 (70-74)	71.3±1.9 (69-74)
Walk on cruches (rate)	0.50	0.17 ^a	0.75 ^a	-	1.0
Walk on walker or wheelchair (rate)	0.50	0.83 ^a	0.25 ^a	1,0	-
Operated extremity – right/left (rate)	0.43/0.57	0.33/0.67	0.50/0.50	0.43/0.57	0.43/0.53

n – number of hips; X ± SD – arithmetic mean ± standard deviation; min-max – minimum-maximum;
^a – p=0,0373 difference statistically significant between men and women

not enhanced the meaning remission of the inflammatory process and situation required the final removing of the implant and casing pendent hip. In these patients the inflammatory process had the long-lasting character (Table II and Table III).

Quality of life assessment results using PAIS criterions

The examination was made in all 14 patients including seven operated which the THR procedure after earlier implantation of SPACER was succeeded with no signs of return to the inflammatory process and the next seven people which despite applying the SPACER had not enhanced the meaning remission of the inflammatory process and situation required the final removing of the implant

causing lameness in flail joint form. In the group with no signs of return the inflammatory process total score middling is 19,16 (+/- 3,01), however in the group with long-lasting inflammatory process total score middling is 47,01 (+/- 2,70).

Clinical examination results

All case-patients were stated the different degree of the limited ability to walk independently (Table I). Seven patients including six female (42.9%) and one male (7.2%) needed to use crutches. The next seven patients including two female (14.4%) and five male (35.8%) were moving with the orthopedic walker or a wheelchair. We noticed the shortening of the operated limb from 1 up to 4 cm in absolute length. The shortening up to 4 cm was confirmed in those patents had

the implant removed.

Radiological examination results

The radiological examination was executed in all operated patients after we completed THR in the AP projection. We stated the inflammation signs as good of diaphysis of femur and in twelve of them (85,7%) as the acetabular cavity. The next seven radiograms showed the presence of Exeter revision endoprosthesis that we used completing THR. At the final 7 people X-ray showed the presence of the flail joint – the most radical way of treatment (Table II and Table III).

Scintigraphic examination results

The radiological examination confirmed by scintigraphic examination with

Table II
Results of alloplastic

Parameters	Total (n=14)	Men (n=6)	Women (n=8)	No success of alloplastic (n=7)	Success of alloplastic (n=7)
Temporary endoprosthesis hold period (months) (X±SD) (min-max)	4.9±0.8 (4.0-6.0)	4.7±0.8 (4.0-6.0)	5.0±0.8 (4.0-6.0)	4.7±0.8 (4.0-6.0)	5.0±0.8 (4.0-6.0)
Observation period from removing of temporal endoprosthesis and performed alloplastics (months) (X±SD) (min-max)	22.6±10.4 (7.0-36.0)	26.2±9.6 (9.0-36.0)	20.0±10.7 (7.0-36.0)	20,4±10,2 (7,0-32,0)	24.9±10.8 (8.0-36.0)
Revision arthroplasty success (rate)	0.50	0.17 ^a	0.75 ^a	0.00 ^c	1.00 ^c
Early diagnosis of septic complication (rate)	0.50	0.17 ^a	0.75 ^a	0.00 ^c	1.00 ^c
Presence of fistula (rate)	0.50	0.17 ^a	0.75 ^a	0.00 ^c	1.00 ^c
Shortening of operated extremity(X±SD) (min-max)	85.4±2.6 (81.0-90.0)	86.3±2.6 (84.0-90.0)	84.8±2.5 (81.0-89.0)	84.7±2.8 (81.0-90.0)	6.1±2.3 (83.0-89.0)
Shortening of opposite extremity to operated extremity (X±SD) (min-max)	87.7±2.9 (83.0-94.0)	89.8±2.5 ^b (87.0-94.0)	86.1±2.0 ^b (83.0-89.0)	88.4±3.1 (84.0-94.0)	87.0±23.65 (83.0-91.0)
Operated joint range of motion flexion/extension (angle/degree)(X±SD) (min-max)	82.5±16.0 (60.0-105.0)	73.3±11.7 (60.0-95.0)	89.4±15.9 (60.0-105.0)	-	-
Operated joint range of motion abduction (angle/degree)(X±SD) (min-max)	17.9±14.0 (0.0-35.0)	10.0±12.6 (0.0-35.0)	23.8±12.5 (5.0-35.0)	-	-
Remission of inflammatory process (rate)	0.50	0.17 ^a	0.75 ^a	0.00 ^c	1.00 ^c

N – number of hips; X ± SD – arithmetic mean ± standard deviation; min-max – minimum-maximum; ^a – p=0.0374 and ^b – p=0.0135 differences statistically significant between men and women; ^c – p=0.0003 difference statistically significant between groups of different effect of alloplastic.

Table III
Results of radiological examination and isotopic marker concentration

Parameters	Total (n=14)	Men (n=6)	Women (n=8)	No success of alloplastic (n=7)	Success of alloplastic (n=7)
Results of radiological examination					
Stump inflammation (rate)	1.00	1.00	1.00	1.00	1.00
Osseous acetabulum infalammation of operated joint (rate)	0.86	1.00	0.75	1.00	0.71
Exeter type revision endoprosthesis (rate)	0.50	0.17 ^a	0.75 ^a	0.00 ^c	1.00 ^c
Presence of pendent hip after removing (rate)	0.50	0.83 ^a	0.25 ^a	1.00 ^c	0.00 ^c
Isotopic marker concentration					
Proximal region of femoral stump (rate)	1.00	1.00	1.00	1.00	1.00
Periacetabular region (rate)	0.86	1.00	0.75	1.00	0.71

N – number of hips; ^a – p=0.0374 and ^b – p=0.0135 differences statistically significant between men and women; ^c – p=0.0003 difference statistically significant between groups of different effect of alloplastic

Table IV
Quality of life score in patient's samples

Parameters	Total (n=14) X±SD (min-max)	Men (n=6) X±SD (min-max)	Women (n=8) X±SD (min-max)	No success of alloplastic (n=7) X±SD (min-max)	Success of alloplastic(n=7) X±SD (min-max)
Health-care orientation	3.94±2.24 (1.60-7.20)	5.30±1.66a (2.10-6.70)	2.92±2.14a (1.60-7.20)	6.04±0.74b (5.20-7.20)	1.84±0.19b (1.60-2.10)
Vocation	7.41±1.89 (4.60-9.80)	8.48±1.70 (5.20-9.80)	6.61±1.70 (4.60-9.30)	9.14±0.51b (8.20-9.80)	5.69±0.74b (4.60-6.90)
Domestic environment	3.81±1.62 (1.80-6.10)	4.80±1.44 (2.10-6.10)	3.06±1.38 (1.80-5.30)	5.29±0.54b (4.60-6.10)	2.33±0.54b (1.80-3.30)
Sexual relationships	2.35±1.88 (0.50-5.40)	3.15±2.20 (0.50-5.40)	1.75±1.47 (0.50-4.50)	3.79±1.65b (0.80-5.40)	0.91±0.38b (0.50-1.40)
Extended family relationships	5.24±2.84 (1.70-8.60)	6.87±2.37 (2.10-8.30)	4.02±2.65 (1.70-8.60)	7.91±0.49c (7.20-8.60)	2.57±0.78c (1.70-3.80)
Social environment	4.71±2.57 (1.60-8.00)	6.38±2.12 (2.20-8.00)	3.46±2.21 (1.60-7.60)	7.14±0.62b (6.30-8.00)	2.29±0.41b (1.60-2.90)
Psychologic stress	5.63±2.33 (2.30-8.90)	6.87±1.85 (3.20-8.20)	4.70±2.31 (2.30-8.90)	7.73±0.68b (7.10-8.90)	3.53±1.02b (2.30-5.20)
Quality of Life – total score	33.10±14.73 (15.30-50.80)	41.85±12.30 (17.40-50.80)	26.54±13.42 (15.30-49.10)	47.04±2.70b (43.00-50.80)	19.16±3.01b (15.30-23.50)

n – number of hips; X±SD – arithmetic mean+standard deviation; min-max – minimum-maximum; a – p=0,0384 difference statistically significant between men and women

Table V
Presence of bacteriological examination in patient's samples

Type of microorganism	Total (n=14)	Men (n=6)	Women (n=8)	No success of alloplastic (n=7)	Success of alloplastic (n=7)
Staphylococcus aureus	35,7 (5)	50,0 (3)	25,0 (2)	71,4 (5)a	-
Staphylococcus epidermis	14,3 (2)	16,7 (1)	12,5 (1)	28,6 (2)	-
Enterococcus faecalis	7,1 (1)	16,7 (1)	-	14,2 (1)	-
Esscherichia coli	7,1 (1)	16,7 (1)	-	14,2 (1)	-
Pseudomonas aeruginosa	7,1 (1)	-	12,5 (1)	14,2 (1)	-

Results are presented as % (number of hips with microorganisms), unless otherwise stated
a – p=0,0072 difference statistically significant between groups of different effect of alloplastic

marked leucocytes was executed in fourteen patients including seven who were implanted revision endoprosthesis Exeter after removing the spacer implant. This examination demonstrated the gathering of the isotopic flag in implant surroundings especially near the closer extremity of a diaphysis what was confirmed in fourteen examined patients and in twelve of them (85,7%) the changes concerned also the area of acetabular cavity (Table II and Table III). The capture degree of the isotopic flag was comparable with the results of scintigraphic examination executed during the primal diagnostics of the septic implant loosening.

Bacteriological examination results

The bacteriological examination was made in patients with active inflammable fistulas, including two female (14,4%) and five male (35,8%). In all examined cases the presence of Staphylococcus aureus, Enterococcus faecialis, Esscherichia coli was confirmed and additionally referring to the previous examinations in one case presence of Pseudomonas aeruginosa was noticed.

Discussion

Total hip replacement has become one of the most successful and common orthopaedic procedures but due to infectious complications and devastating consequences for the hip implant is widely discussed in medical and orthopaedic environment [1,2,5,7]. Chronic refractory femur and coxa osteomyelitis as mentioned complication is the whole life disease causing many a time severe disability. Undoubtedly this situation affects patients quality of life [13,14]. It has been unceasingly reported within the context of major diseases that the nature of psychosocial adjustment to illness is such as important as the physical limitations imposed by disease in determining a quality of life experience [15,16]. For prevention of hip endoprosthesis infection the special attention is dedicated to the necessity of using the antibiotic loaded bone cement in primary and in revision alloplastics [3,4,12,17]. According to Yamamoto et al. and D'Angelo et al., Jahoda et al., and Bertazzoniego et al. the preparation of the patient to the revision alloplastics of hip joint caused by septic

loosening of endoprosthesis should be preceded by implantation of SPACER temporary endoprosthesis [4, 9,10,18].

This problem is also becoming the investigating object of Takahira et al. [19] or Anagnostakos [2]. Essentially, the remarkable problem in the course of septic complications of total hip alloplastic is fast and wide diagnostics. It is not only a clinical and radiological examination but also scintigraphic and bacteriological examinations [10,20,21]. Sanzén et al. are also using C-reactive protein [22]. In our material, the diagnostics of septic hip implant complications was based on the clinical, radiological, scintigraphic and bacteriological examinations. We believe that merging these components allows for deep and fast recognizing of approaching risk of inflammation. Enriching the diagnostics with the activity of Procalcitonin in the blood serum, especially in the early monitoring period is making serious and essential for its supplement. Our study demonstrates that in spite of applying a long-term antibiotic therapy, including aimed antibiotic therapy and SPACER temporary prosthesis is effective only

in the 50% treated patients. These cured patients seem to be in early period of inflammable process. The importance of taking long-term and aim antibiotic therapy and applying antibiotic loaded bone cement is showed by Osmon, Mader et al., Klekamp et al. or Wahlig et al. [20,23-25]. However, applying these procedures is not protecting the infected bone against progression of the inflammatory process. From our own observations based on bacteriological examination - occurs that the primeval bacterial flora had become wider range and in the scyntygraphic examination with marked leucocytes we noticed increasing areas of the deepened capture of the isotopic flag. Using SPACER prosthesis seems to be useful only in the early period of threatening the circumarticular inflammable process. The long-lasting inflammatory process of the bone cause systematic degeneration as well extremity skeleton as modify function of immunological system what in distant observation may rise risk of neoplastic disease and renal insufficiency. Constantly making worse general health condition and presence of permanent lameness cause lack of adjustment these patients to the wide understanding psychosocial function.

Conclusions

1. The long-lasting inflammatory process of the bone complicating THR marked reduced psychosocial adjustment ability to life conditions changed by illness.

2. Diagnostics of the septic complications of total hip alloplastics requires fast and wide clinical procedure not only by clinical and radiological examination but also using scintigraphic, bacteriological

and blood serum tests undertaken immediately after inflammation first signs.

3. Applying of the temporary SPACER in septicly complicated THR is reasonable and should be used in the early observation period.

References

1. **Faris PM, Ritter MA, Keating EM, Thong AE, Davis KE.** The cemented all-polyethylene acetabular cup: factors affecting survival with emphasis on the integrated polyethylene spacer: an analysis of the effect of cement spacers, cement mantle thickness, and acetabular angle on the survival of total hip arthroplasty. *Meding JB Arthroplasty* 2006; 21: 191-198.
2. **Anagnostakos K, Kelm J, Regitz T, Schmitt E, Jung W.** In vitro evaluation of antibiotic release from and bacteria growth inhibition by antibiotic-loaded acrylic bone cement spacers. *J Biomed Mater Res B* 2005; 72: 373-378.
3. **Joseph TN, Chen AL, Di Cesare PE.** Use of antibiotic-impregnated cement in total joint arthroplasty. *J Am Acad Orthop Surg* 2003; 11: 38-47.
4. **Yamamoto K, Miyagawa N, Masaoka T, Katori, Y, Shishido T, Imakiire A.** Clinical effectiveness of antibiotic-impregnated cement spacers for the treatment of infected implants of the hip joint. *J Orthop Sci* 2003; 8: 823-828.
5. **Masri BA, Duncan CP, Beauchamp CP.** Long-term elution of antibiotics from bone-cement: an in vivo study using the prosthesis of antibiotic-loaded acrylic cement (PROSTALAC) system. *J Arthroplasty* 1998; 13: 331-338.
6. **Bertazzoni Minelli E, Caveiari C, Benini A.** Release of antibiotics from polymethylmethacryle cement. *J Chemotherapy* 2002; 14: 492-500.
7. **Magnan B, Regis D, Biscaglia R, Bartolozzi P.** Preformed acrylic bone cement spacer loaded with antibiotics: use of two-stage procedure in 10 patients because of infected hips after total replacement. *Acta Orthop Scand* 2001; 72: 591-594.
8. **Leunig M, Chosa E, Speck M, Ganz R.** A cement spacer for two-stage revision of infected implants of the hip joint. *Int Orthop* 1998; 22: 209-214.
9. **D'Angelo F, Negri L, Zatti G, Grassi FA.** Two-stage revision surgery to treat an infected hip implant. A comparison between a custom-made spacer and a pre-formed one. *La Chirurgia degli Organi di Movimento* 2005; 90: 271-279.
10. **Jahoda D, Sosna A, Landor I, Vavrik P, Pokorný D.** A cannulated articulating spacer-a functional implant for treatment of infected hip joint prostheses. *Acta Chir Orthop Tr* 2004; 71: 73-79.
11. **Comparison with methods used from 1979 to 1998.** *Acta Chir Orthop Tr* 2003; 70: 17-24.
12. **Schoellner C, Fuerderer S, Rompe JD, Eckardt A.** Individual bone cement spacers (IBCS) for septic hip revision-preliminary report. *Arch Orthop Trauma Su* 2003; 123: 254-259.
13. **Derogatis LR.** The psychosocial adjustment to illness scale (PAIS). *Clin Psychometric Res* 1986; 30: 77-91.
14. **Kaplan Der Nour A.** Psychosocial adjustment to illness scale (PAIA): a study of chronic hemodialysis patients. *J Psychosom Res* 1982; 26: 11-22.
15. **Cassileth BR, Lusk EJ, Strouse TB, Miller DS, Brown LL, Cross, PA, Tenaglia AN.** Psychosocial status in chronic illness: A comparative analysis of six diagnostic groups. *New Engl J Med* 1984; 311: 506-511.
16. **De-Nour AK.** Social adjustment of chronic dialysis patients. *Am J Psychiat* 1982; 39: 97-100.
17. **Hanssen AD, Spangehl MJ.** Practical applications of antibiotic-loaded bone cement for treatment of infected joint replacements. *Clin Orthop Relat Res* 2004; 427:79-85.
18. **Bertazzoni Minelli E, Benini A, Magnan B, Bartolozzi P.** Release of gentamycin and vancomycin from temporary human hip spacers in two-stage revision of infected arthroplasty. *J Antimicrob Chemoth* 2004; 53: 329-334.
19. **Takahira N, Itoman M, Higashi K, Uchiyama K, Miyabe M, Naruse K.** Treatment outcome of two-stage revision total hip arthroplasty for infected hip arthroplasty using antibiotic-impregnated cement spacer. *J Orthop Sci* 2003; 8: 26-31.
20. **Osmon DR.** Antimicrobial resistance: guidelines for the practicing orthopaedic surgeon. *Instructional Course Lectures* 2003;51:527-537
21. **Haddad FS, Masri BA, Garbuz DS, Duncan CP.** The treatment of the infected hip replacement. The complex case. *Clin Orthop Relat Res* 1999; 3: 144-156.
22. **Sanzén L, Carlsson AS.** The diagnostic value of C-reactive protein in infected total hip arthroplasties. *J Bone Joint Surg Br* 1989; 71: 638-641.
23. **Mader JT, Wang J, Calhoun JH.** Antibiotic therapy for musculoskeletal infections. *Instructional Course Lectures* 2002; 51: 539-551.
24. **Klekamp J, Dawson JM, Haas D.** The use of vancomycin and tobramycin in acrylic bone cement: biochemical effects and elution kinetics for use in joint arthroplasty. *J Arthroplasty* 1999; 14 : 339-346.
25. **Wahling H, Dingeldein E, Buchholz HW, Buchholz M, Buchmann F.** Pharmacokinetic study of gentamicin-loaded cement in total hip replacements. Comparative effects of varying dosage. *J Bone Joint Surg Br* 1984; 66: 175-179.