Literature review

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Semiotics and problems of terminology for pathological conditions associated with total hip arthroplasty

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Total hip arthroplasty is acknowledged to be a highly effective procedure for treating patients with severe arthritis of the hip joint and it can greatly improve patients' quality of life. However, an increasing number of primary and revision hip arthroplasties is associated with a higher rate of postoperative complications. Terminological confusion at formulating diagnosis for some pathological conditions related to the hip arthroplasty encouraged the authors explore the problem of the semiotics to create a "unified language of communication" for specialists. PubMed and e-library resources were used to search articles containing arthroplasty related terms that were systematized and arranged in a working classification.
Keywords: hip joint, total arthroplasty, terminology

INTRODUCTION

Deforming arthritis of major joints is the most common musculoskeletal condition affecting the locomotor system worldwide. Symptomatic osteoarthritis occurs in 10 % men and 20 % in women aged 60 years or older [1]. Among musculoskeletal conditions affecting joints, the hip is one of the most commonly affected joints with osteoarthritis. Coxarthrosis is the chronic disease characterized by the presence of pain and stiffness which ultimately results in severely impaired locomotion of the patients. Hip osteoarthritis has a significant impact on every-day life activity leading to patient disability with progression of the disease [2, 3].

Total hip replacement (THR) is one of the most successful and effective surgical interventions. It offers tremendous improvement in quality of life, reliable relief of pain and considerable improvement in function to maintain higher level of activity in patients suffering from deforming arthritis of the hip [4]. The mean age of patients receiving elective THR is 68 years and 55 % of surgeries are performed in females according to the Global Orthopaedic Registry published in 2010 [5]. The reasons that require THR include idiopathic and dysplastic deforming arthritis (83 %), rheumatoid arthritis (3 %), avascular necrosis of the femoral head (7 %) and others disorders of the hip joints (7 %) [5]. Although there is no consistency in differentiating types of coxarthrosis and clear distinction between 'idiopathic' and 'dysplastic' conditions, at least in the Russian literature, formulation of diagnosis relies on a 'tradition'. There is no nosological identity for arthritis developing secondary to impingement syndrome that can be termed as either dysplasia or hyperplasia of the hip. Avascular necrosis of the femoral head can be misinterpreted as cystic restructuring of the femoral head in deforming arthritis [6].

With efficient procedure, aging of the population and increasing life expectancy the joint replacements are projected to increase even further. An annual arthroplasty incidence rate is reported to be 100 per 100 000 population according to Rodrigo Jimenez-Garcıa. S. Kurtz estimated the demand for primary THR to grow by 174 % by 2030 [7, 8].

Although THR allows reliable relief of pain and improvements in quality of life the procedure can be associated with failures of hip replacement resulting in persisting pain or greater pain at the surgical

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site, possibility of infection, instability and aseptic loosening of prosthetic components [9]. Because of the increasing number of primary procedures also performed for younger patients, the number of revision THR is expected to increase in the near future. The demand for hip revision procedures is projected to double by the year 2026 with revision THR constituting close to one quarter of all total hip arthroplasties performed in the United States according to S. Kurtz [7]. The increasing number of the procedures has led to a considerable number of THR related pathological conditions unknown in 'pre-arthroplasty era' that encouraged the authors explore terminology of the condition to create a "unified language of communication" for specialists.

Objective To review modern Russian and foreign literature on surgical orthopaedic problems associated with THR for creation of unified terminology and semiotics of the conditions and working formulation.

Reasons for failed THR

Potential reasons for hip revisions can be stratified into three groups: patient related factors, implant related factors and factors related to inadequate surgical technique (iatrogenic failure) [10]. Patient related factors include greater body mass index, poor bone quality (systemic and local osteoporosis), iron deficiency anemia and other patient factors that predispose the patient to loosening of prosthetic components, infection or dislocation [11]. Implant related factors include periprosthetic fracture and loss of adhesive or hydroxyapatite layer providing osseointegration [12, 13, 14]. Iatrogenic intraoperative factors include inadequate implantation of components, inadequate restoration of femoral offset, limb length equality and other surgeon related factors [15]. There is a sufficient number of publications exploring reasons of hip revisions but no well-established conception available for their systemization and semiotics [9, 16, 17].

Lachiewicz et al. retrospectively reviewed 100 consecutive revision THRs to determine the major reason for reoperation. Aseptic loosening of both components was the commonest reason for implant failure that occurred in 38 % of the cases. Other indications for revision were: loosening of acetabular component (22 %), loose hemiarthroplasty (13 %), infection (10 %), loosening of femoral component (8 %), periprosthetic fracture (6 %), recurrent dislocation (2 %), and polyethylene wear (1 %) [16]. The authors did not use the term 'instability' describing reasons for revision in 100 cases.

Slif D. Ulrich el al. conducted the study to evaluate the indications for revision THR. A review identified 225 patients who underwent 237 revisions. The overall mean time to revision was 83 months (range, 0–360 months). The reasons of failure included aseptic loosening (51.9 %), instability (16.9 %), infection (15.6 %), marked pain symptom (8 %), periprosthetic fracture (5,5 %) component failure (2.1 %) [9]. Interestingly, the term 'instability' was used to denote dislocation and the term 'dislocation' was not used identifying the indications for revision hip surgery.

Clohisy et al. determined the indications for revision hip surgery in a retrospective review of 439 revision hip surgeries done between August 1996 and September 2003. Procedures were stratified into three groups on the basis of the time to failure. Fifty-one percent of the surgeries were for aseptic loosening, 18 % were for instability, 11 % were for sepsis, 7 % were for conversion of a hemiarthroplasty, 4 % were for osteolysis, 3 % were for iliopsoas impingement, 3 % were for periprosthetic fracture of the femur, and 1 % was for periprosthetic acetabular fracture in the first group (< 5 years). The major cause of failure at mid-term (5–10 years) was aseptic loosening (57 %). Other mid-term reasons included osteolysis (18 %), instability (11 %), periprosthetic fracture (4 %), conversion of a hemiarthroplasty (4 %), sepsis (3 %) and implant fracture (1 %). Again, aseptic loosening (61 %) was the commonest reason for hip revision at a longer term (more than 10 years) with other causes including osteolysis (26 %), periprosthetic fracture of the femur (8 %), conversion of a hemiarthroplasty (3 %), sepsis (1 %) and iliopsoas impingement (1 %) [17]. The term 'instability' was used in the article to denote dislocation and the term 'dislocation' was not mentioned for identification of the reasons for revision hip surgery. However, the authors referred to research of Paprosky et al. who performed identical review

and reported implant dislocation in 16 % of the cases that led to acetabular component revision. The term 'dislocation' [18] was used by the authors and might be misleading for a clear understanding of the issue.

Aseptic loosening is considered as the most common complication of joint replacement surgeries. Haddad et al. evaluated outcomes of total ankle replacement in a meta-analysis with the primary reason for revisions being loosening of endoprosthetic components [19]. High rate of aseptic loosening among the indications to revision arthroplasty led the authors to think of a more accurate interpretation of the term. Murray J. Penner et al. described the term 'aseptic loosening' as 'non-infected loss of fixation between the bone and the implant in presence of micro- and macromobility between them' [20]. Yousef Abu-Amer described aseptic loosening as the result of inadequate initial fixation, mechanical loss of fixation over time, or biological loss of fixation caused by particle-induced osteolysis around the implant described in different theories, associated with latent infection, increased intraarticular pressure, etc. [21, 22, 23]. Micromotion that cannot be visualized with routine imaging modalities is a precursor of aseptic loosening that is irreversible. In 1994 Goodman described the condition as 'minor motion between the implant and the bone that is undetectable with radiography' [24]. With less specificity of the conventional imaging for evaluation of the condition radioisotopic evaluation has become the gold standard for detecting micromotion of implant relative to the surrounding osseous structures. In 1994 Karrholm et al. reported the cut-off value for the probability of revision surgery to exceed 50 % was 1.2 mm of subsidence at two years [25]. Despite considerable strategic importance of diagnosis the condition is not identified as a stand-alone complication of joint replacement and further research is needed in this matter.

Periprosthetic stress shielding is a scientifically proven phenomenon which leads to mechanical bone loss due to redistribution of load first described by Oh and Harris in 1978. Stress shielding is caused rather by pathological transformation of osseous structure than osteolysis [26]. Trabecular bone deficits across the whole proximal femur contribute to the bone fragility exerting an adverse effect on bearing surfaces through polyethylene and metal wear debris, increased intraarticular pressure that results in aseptic loosening of acetabular and femoral components [27, 28]. The term stress-shielding is in common use in English literature and transliterated for Russian users to facilitate comprehension in absence of adequate orthopaedic glossary. Although the term was translated into Russian as 'bypassing load syndrome' the Russian version was popular neither in clinical use and nor in publications [29].

Jens Dargel et al. reported on dislocations following THR and defined the complication "as the complete loss of articulation between two artificial joint components". The authors identified four pathological conditions leading to implant dislocations: implant malpositioning or aseptic loosening of femoral or acetabular components, contact between neck of the prosthesis and articular component, contact between bony femur and bony pelvis and hyperlaxity of the joint due to muscular insufficiency or lack of soft tissue tension [30]. The three most common risk factors for THR dislocation were patient related factors, surgeon related factors and implant related factors. A higher risk group included patients with cerebral palsy, muscle dystrophy, dementia and Parkinson's disease. For the population of patients older than 80 years, an increased risk of dislocation was attributed to sarcopenia, loss of proprioception and the increased risk for falls. Revision THR after previous dislocation, periprosthetic fractures and aseptic or septic loosening were associated with dislocation rates of up to 28 % due to multiple injuries to soft tissues, extensive scarring, heterotopic ossification of the hip and acetabular or femoral bone loss. Procedure-specific risk factors for THR dislocation included surgical approach, positioning of the acetabular and femoral components, soft-tissue tension and the surgeon's experience. Implant related factors included use of smaller head diameter (28 mm) that led to higher dislocation rate as compared to application of larger femoral heads [30]. Understanding of the high-impact factors contributing to the dislocation risk is very important also because of the existing incoherence between "dislocation" and

"instability" that is described as an impaired function of components in the Russian literature.

Luis Pulido et al. presented studies on late instability following THR and described instability as two inter-related yet distinct conditions, dislocation in which the femoral head was completely out of the acetabulum and subluxation in which the femoral head was partially out of the acetabulum [31]. We formulated the term in a different way using content-analysis. Instability of the hip prosthesis was termed as a pathology associated with static or dynamic impairment of congruency of articulating prosthetic components. Dislocation and subluxation of the prosthetic femoral head and other pathological conditions leading to incongruent prosthetic articulations can be referred to this group of disorders. Dissociation of articular surfaces is a dominant pathological phenomenon versus loosening of prosthetic components with impaired mechanical junction of femoral and acetabular components. It should be noted that loosening of components can occur in stable joint in well associated prosthetic articulations.

Deep surgical site infections (SSIs) or periprosthetic joint infections (PJIs) [32] termed as "paraendoprosthetic infection" [33] or "periprosthetic infection" [34] in the Russian literature is a devastating complication following THR. Despite the nearly identical meaning of the last two terms "periprosthetic infection" can be recommended for use because prefix "peri" means "about" or "around", "enclosing" or "surrounding" and "near", whereas "para" is defined as "next to", "beyond" or "assistant to" and also as "deviation, divergence, derangement, false identification, mismatch in the entity appearance and occurrence" (parapsychology, parascience, paramedicine) making the term less specific [35, 36].

Working formulation of THR related pathological conditions was developed to outline different terms associated with total hip arthroplasty (Table 1).

Table 1

Classification of pathological conditions associated with THR surgery

Instability of THR (type I complication)	Impaired mechanical fixation of prosthetic components or implant wear (type II complication)	Periprosthetic fracture (type III complication)	Deep surgical site infection (type IV complication)
1. Iatrogenic instability (reasons): • inadequate positioning of components (impingement caused by decreased or excessive anteversion of acetabular component or inadequate ante- or retroversion of femoral component) • inadequate restoration of femoral offset • inadequate restoration of limb length equality • dislocation of unipolar and bipolar prosthesis (inadequate choice of implant for "open type of the acetabulum") • intraoperative injury to nerves and resultant neurological deficiency 2. Instability associated with passive implant stabilizers: • dissociated components of dual-mobility system • dissociated modular prosthetic components • dissociation or mechanical breakage of standard prosthetic components 3. Instability associated with active implant stabilizers: • dysfunction of the gluteus medius muscle due to functional injury • dysfunction of the gluteus medius due to mechanical injury	1. Aseptic loosening of prosthetic components 2. Septic loosening of prosthetic components 3. Radiotranslucent lines around prosthetic components 4. Axial pathological mobility of cemented polished femoral stem 5. Axial pathological mobility of cemented stem and the femoral cement mantle 6. Inadequate cement distribution in the femoral canal and cement mantle failure 7. Fractured cement mantle of acetabular or femoral component 8. Stress shielding 9. Polyethylene wear	Periprosthetic fracture of the femur or acetabulum	Periprosthetic infection

CONCLUSION

A great number of THR surgeries are performed worldwide and in our country, in particular, and there is a significant pool of patients who develop complications following the procedure that affect limb function and health-related quality of life. Adverse effects of THR include loosening of prosthetic components, implant wear or instability (static or dynamic dissociation of articulating surfaces) and deep surgical site infection. A diversity of terms used to describe the types of pathologies and a variety of theories of their origin can be misleading in informal clinical interactions and specialized literature and initiated creation of the working formulation. The classification can be the first step to orthopaedic glossary to systematize the variety of pathological conditions associated with THR providing a "unified language of communication" for specialists.

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