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Review

Classification of hip joint infections

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Abstract

Infections still remain one of the most devastating complications in hip joint surgery. Classification of these infections help the orthopaedic surgeon to identify the acuteness or chronicity of the infection, predict the complexity of the treatment procedure and ensure that all necessary device are available at the time of the revision surgery. The present article reviews the actual literature and provides an overview of clinical, arthroscopic, microbiological and radiological staging systems.

Key words: hip joint infection, early infection, late infection, low-grade infection

Introduction

Approximately 170,000 primary total hip arthroplasties are performed in Germany annually [10]. Despite numerous prophylactic measures infections still occur in 1-2 % of these cases, whereas this rate may increase after revision surgery [1]. This means that between 1000 and 2500 patients per year will become infected. Similar figures are reported in the United States [16]. Moreover, the overall infection rate is likely to increase as the life expectancy of the implants is increased and patients are followed up longer. Depending on the time of infection manifestation, presence of any hardware, virulence and antibiotic profile of the pathogen organism, and the general medical condition of the patient, several treatment options are available including both one- and two-stage procedures.

These infections require often demanding management procedures which can be associated with prolonged and complicated treatment courses. Classification of hip joint infections allows the orthopaedic surgeon not only to define the actual status of the infected joint, but also choose the most adequate treatment option, plan the prosthesis reimplantation in case of a hardware explantation and make any statements regarding the prognosis.

In this review article, the current status about classification of hip joint infections is presented.

Classification of hip joint infections

The major aim of a classification system for hip joint infections is to help the orthopaedic surgeon identify the acuteness or chronicity of the infection, predict the complexity of the treatment procedure and ensure that all necessary devices are available at the time of the first revision surgery as well as of further surgical interventions, if necessary. Moreover, a classification system should also permit a valid and reliable comparison of results from similar case mixes. However, due to a variety of different classification systems, there is currently no consensus as to which system is the most appropriate in reflecting the actual severity of the infection, determining the femoral or acetabular bone defects or choosing the ideal treatment procedure.

Generally, hip joint infections can be divided into primary (e.g. bacterial coxitis) and those in the

presence of any implants (e.g. total hip replacement). A specific coxitis classification does not exist, however, the arthroscopic classification system according to Gächter seems to be applicable also for the hip joint, although initially described for the knee joint [8]. This classification system consists of 4 stages (Table 1) and combines intraarticular findings of the soft tissues as well as radiological alterations of the infected joint. Infections classified up to stage III can be arthroscopically treated, whereas stage IV requires open revision surgery.

Table 1: Arthroscopic classification of joint infections according to Gächter [8].

Stage I	opacity of fluid, redness of the synovial membrane, possible petechial bleeding, no radiological alterations
Stage II	Severe inflammation, fibrinous deposition, pus, no radiological alterations
Stage III	thickening of the synovial membrane, compartment formation, no radiological alterations
Stage IV	aggressive pannus with infiltration of the cartilage, undermining the cartilage, radiological signs of subchondral osteolysis, possible osseous erosions and cysts

The time of infection manifestation is also an important factor in classifying hip joint infections. Historically, infections have been classified in acute and chronic ones. Over the years it has become apparent that a further differentiation depending on the exact time of infection manifestation is required. Therefore, hip joint infections are actually categorized into early, delayed, and late infections [12, 20]. Although these terms are widely accepted, a discrepancy regarding the precise differentiation of the time periods still exists. Some authors define all infections within the first 6 postoperative weeks as early, whereas others extend this period until the first 12 postoperative weeks. Early infections are attributed to an intraoperative contamination. Between this specific time and the first 24 months after surgery, infections are defined as delayed. Delayed infections are also attributed to an intraoperative contamination, however, an infection manifestation has not evolved due to a small bacteria number, low virulence of the causative organism or adverse local conditions for bacteria growth. Late infections emerge after the first 2 postoperative years. These infections are hematogenously acquired, whereas in 20-40 % of the cases the primary infection source remains unidentified [12]. In the past years, the term of a low-grade infection has also been introduced for describing subacute, prolonged infections with lack of any typical local infection signs. Histopathological and microbiological findings might be positive. Practically, all these definitions are an attempt to separate surgically from nonsurgically acquired infections, and the problem is where to draw the line. Clearly, not every early infection is surgically acquired and not all late infections are from other sources.

Depending on the infection localization, infections can be divided into superficial and deep. A superficial infection is limited to the higher wound layers and can be easily treated in most cases by debridement and pulsatile lavage. On the other hand, deep infections that reach the prosthesis are more difficult to treat. Besides a meticulous surgical debridement and pulsatile lavage, the cup inlay and the prosthesis head should be exchanged in order to prevent any further bacteria colonization and growth [13]. In case of a combined late and deep infection it seems unlikely to achieve an infection eradication under prosthesis preservation.

Depending on the causative pathogen organism, infections can be divided into bacterial and fungal ones. Bacterial infections can be further classified as gram-positive or –negative and mono- or multibacterial. This differentiation helps the surgeon especially in making the appropriate choice for the treatment procedure. Ure at al. emphasized that a direct exchange arthroplasty can only be carried out in early infections, and if the infecting organism is of low virulence (no methicillin-resistant or gram-negative bacteria) [22]. Moreover, the resistance profile of the causative bacterium might be associated with prolonged and complicated treatment courses. Kilgus et al. evaluated periprosthetic hip joint infections caused by antibiotic-sensitive and –resistant bacteria [14]. The authors concluded that hip replacements infected with antibiotic-sensitive bacteria were treated successfully in 81 % of the cases, whereas arthroplasties infected with resistant bacteria were treated successfully in only 48 % of the cases.

Fungal infections are rare, but commonly found in immunosuppressive patients and associated with complications and infection persistence [15]. A possible explanation for that might be the fact that a local antifungal therapy does not reach as high antimicrobial concentrations for longer periods as antibiotic-impregnated cement device in the treatment of bacterial infections do. Moreover, in cases with infection persistence despite surgical debridement and systemic antibiotics but no primary bacterial identification, orthopaedic surgeons should always keep in mind that a fungal infection might be the reason for that.

Table 2: Staging system for periprosthetic infections according to McPherson [16].

Infection Type	Systemic Host Grade	Local extremity grade
I: early postoperative infection	A: uncompromised	1: uncompromised
(< 4 postoperative weeks)	B: compromised	2: compromised
II: hematogenous infection	(1-2 compromising factors)	(1-2 compromising factors)
(< 4 weeks duration)	C: significant compromise	3: significant compromise
III: late chronic infection	(> 2 compromising factors) or one of	(> 2 compromising factors)
(> 4 weeks duration)	- absolute neutrophil count < 1000	
	- CD4 T cell count < 100	
	- intravenous drug abuse	
	- chronic active infection at	
	another site	
	- dysplasia or neoplasm of the	
	immune system	
	Compromising factors:	Local extremity grade (wound)
		compromising factors
	- age > 80	- active infection present
	- immunosuppressive drugs	> 3-4 months
	- alcoholism	- multiple incision with skin
	- malignancy	bridges
	- chronic active dermatitis or cellulites	- soft tissue loss from prior trauma
	- pulmonary insufficiency	- subcutaneous abscess > 8 cm^2
	- chronic indwelling catheter	- synovial cutaneous fistula
	- renal failure requiring dialysis	- prior periarticular fracture or
	- chronic malnutrition	trauma about a joint
	- systemic inflammatory disease	- prior local irradiation
	- current nicotin use	- vascular insufficiency to extremity
	- systemic immune compromise	
	- diabetes	
	- hepatic insufficiency	

Based on the afore mentioned data, McPherson et al. developed a staging system for periprosthetic hip infections taking into consideration the acuteness of the infection, the overall medical and immune health status of the patient, and the local wound condition (Table 2) [17]. The classification of each infection may assist the surgeon identify the severity of each infection case and choose an appropriate treatment option. The system has been used in clinical practise especially in the United States and the United Kingdom [11, 18].

Tsukayama et al. proposed a 4-stage system consisting of early postoperative-, late chronic-, and acute hematogenous infections, and positive intraoperative cultures of specimens obtained during revision of a presumed aseptically loose total hip prosthesis [21].

Cierny and DiPasquale tried to adjust the Cierny classification system for osteomyelitis in adult patients [4] also for the classification of periprosthetic total joint infections [3]. In this system, prosthetic joint infections are entered as anatomic types of the disease: early and superificial osteomyelitis (Type II) or late and refractory osteomyelitis (Type IV of the initial osteomyelitis staging system). Besides this anatomic differentiation, the authors added local and systemic host factors that may affect treatment and prognosis. In this system, patients are categorized as A-, B-, or C-hosts. A-hosts are healthy and without healing deficiencies. B-hosts are compromised by one or more local and/or systemic parameters (Table 3). C-hosts are patients for whom the morbidity of cure far exceeds that of their illness or surpasses their capacity to withstand curative treatment. C-hosts are not considered candidates for aggressive surgical intervention but rather for conservative treatment.

Table 3: Local and systemic host factors that may affect treatment and prognosis of periprosthetic joint infections according ot Cierny and DiPasquale [4].

$B^{(L)}$ - Host	$B^{(S)}$ - Host
(local compromise)	(systemic compromise)
chronic lymphedema	malnutrition
venous stasis	immune deficiencies
major vessel disease	chronic hypoxia
Arteritis	malignancies
extensive scarring	diabetes mellitus
radiation fibrosis	extremes of age
retained foreign bodies	(-2 years, + 70 years)
(suture, buckshot)	chronic nicotin abuse
	current nicotin abuse
	major organ failure

A specific radiological evaluation of hip joint infections does not exist to our knowledge. However, several authors have used different radiological systems that have been primarily developed for determining acetabular and femoral defects at the site of an aseptic loosening of hip arthroplasties also in the assessment of infected total hip replacements. The Paprosky- [7, 19], and the AAOS (American Academy of Orthopedic Surgeons) [5-6] classifications belong to the most widely used ones.

Paprosky has developed two systems for classification of acetabular (Table 4) [19] and femoral defects (Table 5) [7], respectively. Acetabular and femoral defects must be separately assessed, although a combined assessment is needed at the time of surgery. Both classification systems allow for the prior choice of which prosthesis to use at the time of reimplantation, and which type of graft depending on whether or not the residual bone guarantees mechanical hold of the implant.

The American Academy of Orthopaedics Surgeons (AAOS) classification system for acetabular and femoral defects (Table 6) has been described by D'Antonio and colleagues [5-6]. Regarding the acetabular deficiencies, the system has two basic categories: segmental and cavitary. A segmental deficiency is any complete loss of bone in the supporting hemisphere of the acetabulum (including the medial wall). Cavitary defects represent a volumetric loss in bony substance of the acetabular cavity, but the acetabular rim remains intact. Pelvic discontinuity is a defect across the anterior and posterior columns with total separation of the superior from the inferior acetabulum. Arthrodesis implies no deficiency because the entire bony cavity is filled with bone, but it represents a technical deficiency because the location of the true acetabulum can be a problem. Similar to the acetabular classification, femoral deficiencies can also be divided into segmental and cavitary ones. A segmental defect is defined as any loss of bone in the supporting cortical shell of the femur. A cavitary defect is a contained lesion and represents an excavation of the cancellous or endosteal cortical bone with no violation of the outer cortical shell of the femur. Segmental proximal deficiencies can be further subdivided into partial and complete. Cavitary defects are classified according to the degree of bone loss within the femur. Cancellous cavitary defects involve only the cancellous medullary bone. Cortical cavitary defects suggest a more severe type of erosion where, in addition to the cancellous bone, the femoral cortex is eroded from within. Malalignment abnormalities can be either in rotational or angular direction. Femoral stenosis is a separate category and involves the relative or absolute narrowing of the femoral canal. Finally, femoral discontinuity describes the lack of bony integrity that exists with fractures of the femur with or without an implant present.

Table 4: Paprosky classification of acetabular defects [18].

Type	Relationship of component to the Köhler line	Vertical migration	Ischial lysis	Tear drop
I	lateral	minimal	minimal	intact
IIa	medial	minimal	minimal	intact
IIb	lateral	approaching 2 cm	minimal	intact
IIc	medial	minimal	minimal	violated
IIIa	lateral	> 2 cm	mild/moderate	intact
IIIb	line violated	> 2 cm	severe	violated
Type I indicates an intact and supportive acetabular rim, with no migration of the component, no evidence of osteolysis in the ischium or tear drop and no violation of the Köhler line.				
Type II indicates adequate host bone remaining to support a cementless acetabular component and > 50 % host bone support, with < 2 cm or superior migration of the hip centre from superior obturator line and no major osteolysis of the ischium or tear drop (ischial osteolysis of < 7 mm below the obturator line).				
Type IIIa indicates> 2 cm of superior and lateral migration of the component above the obturator line with mild to moderate ischial lysis. The component is at or lateral to the Köhler line and the ilioischial and iliopubic lines are intact. The failed component migrates superiorly and laterally.				
Type IIIb indicates more extensive ischial osteolysis (> 15 mm below the obturator line), complete destrcution of the tear drop, migration medial to the Köhler line, and > 2 cm of superior migration of the component cephalad to the obturator line. The failed component migrates superiorly and medially.				

Table 5: Paprosky classification of femoral defects [7].

Type	Criteria
I	Minimal loss of metaphyseal cancellous bone, intact diaphysis
II	Extensive loss of metaphyseal cancellous bone, intact diaphysis
IIIa	metaphysis not supportive, > 4 cm bone in the diaphysis for distal fixation
IIIb	metaphysis not supportive, < 4 cm bone in the diaphysis for distal fixation
IV	extensive metaphyseal and diaphyseal damage in conjunction with a widened femoral canal

Table 6: The classification system of the American Academy of Orthopaedic Surgeons (AAOS) of acetabular and femoral deficiencies in total hip replacement [5-6].

Acetabulum	Femur
I Segmental deficiencies	I Segmental deficiencies
Peripheral	II Cavitary deficiencies
Superior	III Combined deficiencies
Anterior	IV Malalignment
Posterior	V Femoral stenosis
Central (medial wall absent)	VI Femoral discontinuity
II Cavitary deficiencies	
Peripheral	
Superior	
Anterior	
Posterior	
Central (medial wall intact)	
III Combined deficiencies	
IV Pelvic discontinuity	
V Arthrodesis	

Discussion

There exists a variety of classification and staging systems for joint infections. Certainly, only few orthopaedic surgeons are familiar with all systems. The aim of this article was to review the most important and widely used systems and definitions and outline some pros and contras in their clinical use and assessment of hip joint infections.

Generally, a valid and reliable staging system should facilitate comparison of patients treated for joint infection between institutions and allow analysis of outcomes in specific patient groups when treated in a similar manner. Analysis of treatment outcomes by patient subgroups within a staging system potentially could be then used to establish treatment guidelines.

The abovementioned radiological classification systems have been evaluated by various studies regarding reliability and validity. The validity of the system is the relationship between the actual bone deficiency and the deficiency predicted by the classification. The reliability refers to its consistency among users of the classification. Intraobserver reliability is the agreement between the same observer on separate occasions. Agreement between ≥ 2 observers is referred to as interobserver reliability. Campbell et al. evaluated the Paprosky- and AAOS classifications for their reliability and found only a poor inter- and intraobserver reliability [2]. Gozzard et al. showed a good validity for the Paprosky acetabular classification system but only a moderate for the femoral system [9].

Depending on the particular classification or staging system various treatment protocols have been proposed for infection management. In the study by Tsukayama et al. [21], infections that were diagnosed on the basis of positive intraoperative cultures were treated with intravenous administration of antibiotics for six weeks without surgical intervention, and a success rate of 90 % was reported. Early postoperative infections were treated with debridement, prosthesis retention, and administration of antibiotics; this protocol had a success rate of 71 %. Late chronic infections were treated with use of a two-stage exchange protocol with a success rate of 85 %. Finally, acute hematogenous infections were treated with debridement, retention of the prosthesis, and intravenous administration of antibiotics; 50 % of the infections were treated successfully [21]. In the study by Cierny and DiPasquale [3], patients with type II infections were offered prosthetic salvage, regardless of the host status. These patients were treated with debridement, complete synovectomy, exchange of all polyethylene components and lavage. Patients with type IV infections had all prosthetic components removed; antibiotic-loaded beads or spacers have been used in the management of these infections. The authors reported a success rate of 87 % of the patients with early and 64 % of those with late infections.

According to their system, McPherson et al. evaluated 50 cases of type III infections at the site of total hip replacement that were all treated with resection arthroplasty and intravenous administration of

antibiotics [17]. The reimplantation rate was only 58 %, with a mortality rate of 10 %. The authors found also significant correlations of systemic host grade to various outcome parameters. A strong correlation was seen between systemic host grade and having one or more complications. A relationship of worsening systemic host grade was correlated with amputation rate. A positive correlation existed between systemic host grade and reimplantation. Correlations of local extremity grade to outcome parameters were observed, too. A correlation was seen between worsening local extremity grade and having one or more complications. An important correlation found was the relationship of local extremity grade and the use of muscle flap transfer. There were no correlations between local extremity grade with amputation or permanent resection, respectively.

Due to emergence of new multiresistant bacterial strains, modifications in the treatment philosophy of infected joints as well as an increasing number of comorbidities among patients that suffer from joint infections, staging and classification systems should be routinely updated over the years. In an evaluation of the McPherson staging system, Hanssen and Osmon recommended consideration of excluding infection chronicity as a separate variable in the local wound grade because this variable is redundant by already being accounted for in the categorization of infection type [11]. Hereby, additional variables that should be considered for inclusion in the staging system include primary versus revision surgery, classification of the magnitude of acetabular and femoral bone loss, use of massive structural allografts, and the presence of multiresistant bacteria, such as methicillin-resistant staphylococci or vancomycin-resistant enterococci.

To our knowledge, there exists no system that is universally accepted and acts as gold standard in the exact definition and description of hip joint infections. Apparently, all classification systems contribute to the treatment and prevention of these infections by requiring the physician to acknowledge and record factors affecting the multiple domains of wound healing; however, they all have pros and contras. Perhaps, it would be advisable to conduct a large multi-center study in order to record and identify all influencing parameters and different treatment strategies and, hence, establish guidelines for the management of hip joint infections. Until such a study is carried out, orthopaedic surgeons should be aware of the various infection staging systems, classify patients with hip joint infections as detailed as possible (to our opinion, most cases can be sufficiently documented according to the McPherson classification), and try to identify new possibly influencing parameters that have not been described, yet.

Conflict of Interest

The authors have declared that no conflict of interest exists.

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