CONCORSO PUBBLICO per titoli ed esami per la copertura a tempo indeterminato di n.1 posto di DIRIGENTE MEDICO – disciplina: ORTOPEDIA E TRAUMATOLOGIA (SCADUTO IL 09/08/2021- ESPLETATO IL 29/10/2021); assolvimento obbligo aziendale di pubblicazione ai sensi dell'art. 19 del D.lgs 33/2013 come modificato dal D.lgs 97/2016	
PROVE SCRITTE	
PROVA SCRITTA N. 1	VEDI ALLEGATO N. 1
PROVA SCRITTA N. 2	VEDI ALLEGATO N. 2
PROVA SCRITTA N. 3	VEDI ALLEGATO N. 3
PROVE PRATICHE	
PROVA PRATICA N. 1	VEDI ALLEGATO N. 4
PROVA PRATICA N. 2	VEDI ALLEGATO N. 5
PROVA PRATICA N. 3	VEDI ALLEGATO N. 6
PROVE ORALI	
PROVA ORALE N. 1	VEDI ALLEGATO N. 7
PROVA ORALE N. 2	VEDI ALLEGTAO N. 8
PROVA ORALE N. 3	VEDI ALLEGATO N. 9

CRITERI DI VALUTAZIONE DELLA COMMISSIONE - PROVE

Prova scritta, Prova pratica, Prova Orale

Grado di approfondimento della conoscenza dell'argomento o degli argomenti costituenti la prova per quanto riguarda il contenuto; capacità di collegarli in successione conseguente; adeguata conoscenza dei termini tecnico-scientifici necessari per la corretta esposizione del contenuto; proprietà del linguaggio e capacità espositiva.

Il punteggio da assegnare alla prova, in misura inferiore, uguale o superiore alla soglia di sufficienza terrà conto del grado di presenza degli aspetti elencati ed eventualmente di altri ad essi riconducibili, presenti nel corso della trattazione.

CRITERI DI VALUTAZIONE DELLA COMMISSIONE - TITOLI

La commissione determina di attenersi ai seguenti criteri per la valutazione dei titoli:

1. i servizi verranno valutati fino alla data di rilascio del relativo certificato, ovvero fino alla data della dichiarazione sostitutiva di certificazione;
2. per i periodi non specificamente determinati, le annate saranno calcolate dal 31 dicembre del primo anno al 1° gennaio dell'ultimo anno, mentre le mensilità saranno calcolate dall'ultimo giorno del primo mese al primo giorno dell'ultimo mese;
3. le attività svolte presso cliniche o istituti universitari e riferiti ad anni accademici saranno valutati dal 1° novembre al 31 ottobre dell'anno successivo, salvo diversa indicazione;
4. di valutare esclusivamente i servizi effettivamente prestati e di non tenere conto di lettere di elogio, di partecipazioni di nomina ad uffici od incarichi, quando non risulti lo svolgimento dei medesimi;
5. non saranno valutati attestati laudativi.

Ciò premesso, per quanto riguarda la valutazione riferita alle categorie specifiche dei titoli, la commissione determina i seguenti criteri:

A) Titoli di carriera (max p. 10)

per la valutazione dei titoli di carriera verranno applicati i principi di cui al 4° comma dell'art. 27 del citato DPR 483/97.

Ai sensi dell'art. 45 del D.Lgs. 368/99 il periodo di formazione specialistica è valutato fra i titoli di carriera come servizio prestato a tempo pieno nel livello dirigenziale a concorso (punti 1,200 / anno)

Il periodo valutato è pari alla durata legale del corso di studi.

B) Titoli accademici e di studio (max p. 3)

verranno attribuiti i punteggi di cui al comma 5 del suddetto articolo 27, ad eccezione della specializzazione nella disciplina oggetto del concorso, tenuto conto di quanto specificato alla lettera A)

C) Pubblicazioni, titoli scientifici (max p. 3)

la commissione stabilisce di attenersi ai seguenti criteri di valutazione sulla scorta di quanto previsto dall'art. 11 del D.P.R. 483/97:

- originalità della produzione scientifica;
- importanza della rivista;
- continuità e contenuti dei singoli lavori;
- grado di attinenza dei lavori stessi con la posizione funzionale da conferire;
- eventuale collaborazione di più autori.

La commissione peraltro terrà conto, ai fini di una corretta valutazione:

⇒ della data di pubblicazione dei lavori in relazione all'eventuale conseguimento di titoli accademici già valutati in altra categoria di punteggi;

⇒ del fatto che le pubblicazioni contengano mere esposizioni di dati e casistiche, non adeguatamente avvalorate ed interpretate, ovvero abbiano contenuto solamente compilativo o divulgativo, ovvero ancora costituiscano monografie di alta originalità.

Qualora non fosse possibile individuare l'apporto del candidato la commissione ritiene che il lavoro debba essere attribuito in parti uguali a tutti gli autori.

D) Curriculum formativo e professionale (max p. 4)
fermi restando i criteri fissati dall'art. 11 del D.P.R. 483/97 la commissione procederà alla valutazione ponendo adeguata motivazione, che verrà inserita in calce alle schede, avuto riguardo ai singoli elementi documentali che hanno contribuito a determinare il punteggio globale sulla base dei criteri indicati nel suddetto articolo:

- sono valutate le attività professionali e di studio, formalmente documentate, non riferibili a titoli già valutati nelle precedenti categorie, idonee ad evidenziare, ulteriormente, il livello di qualificazione professionale acquisito nell'arco della intera carriera e specifiche rispetto alla posizione funzionale da conferire nonché gli incarichi di insegnamento conferiti da enti pubblici;
- rientra, altresì, la partecipazione a congressi, convegni e seminari che abbiano finalità di formazione e aggiornamento professionale e di avanzamento di ricerca scientifica.

PROVA SCRITTA N 1 ALLEGATO N 1

Caratteristica della frattura da osteopetrosi

- ☐ Dolore nelle settimane precedenti la frattura
- ☐ Consolidazione rallentata
- ☐ Fallimento della sintesi
- ☐ Fragilità a monte ed a valle della sintesi
- ☐ Tutte le precedenti
- ☐ Nessuna delle precedenti

Pseudoartrosi in esiti di sintesi: fattori da considerare

- ☐ Infezione
- ☐ Vascolarizzazione
- ☐ Meccanica
- ☐ Biologia del paziente
- ☐ Tutte le precedenti

DAIR (debridement, antibiotics, irrigation, and retention) per il trattamento delle infezioni periprotesiche

- ☐ è concetto superato del tutto
- ☐ può essere considerato se infezione immediatamente postintervento, agente batterico agevolmente trattabile e paziente in buone condizioni mediche
- ☐ può essere considerato indipendentemente dal tempo trascorso dall'impianto, se infezione verificata per via ematogena, a prescindere dall'agente batterico, se il paziente è in buone condizioni mediche

Finestre di opportunità per il trattamento di un paziente politraumatizzato

- ☐ giorno 1= damage control oppure early total care
giorni 2-4= solo medicazioni
giorni 5-10= chirurgia restituiva definitiva
giorni 11-21= nessun tipo di chirurgia
dopo il giorno 21= chirurgia sostitutiva e correttiva
- ☐ giorno 1= damage control oppure early total care
giorni 2-4= chirurgia restituiva definitiva
giorni 5-10= solo medicazioni
giorni 11-21= chirurgia sostitutiva e correttiva
dopo il giorno 21= nessun tipo di chirurgia
- ☐ più appropriato eseguire sempre ETC: early total care
- ☐ più appropriato considerare EAC: early appropriate care.

PROVA SCRITTA N 2

ALLEGATO N C

Caratteristica della frattura da osteopetrosi

- ☐ Dolore nelle settimane precedenti la frattura
- ☐ Consolidazione rallentata
- ☐ Fallimento della sintesi
- ☐ Fragilità a monte ed a valle della sintesi
- ☐ Tutte le precedenti
- ☐ Nessuna delle precedenti

Pseudoartrosi in esiti di sintesi: fattori da considerare

- ☐ Infezione
- ☐ Vascolarizzazione
- ☐ Meccanica
- ☐ Biologia del paziente
- ☐ Tutte le precedenti

DAIR (debridement, antibiotics, irrigation, and retention) per il trattamento delle infezioni periprotesiche

- ☐ è concetto superato del tutto
- ☐ può essere considerato se infezione immediatamente postintervento, agente batterico agevolmente trattabile e paziente in buone condizioni mediche
- ☐ può essere considerato indipendentemente dal tempo trascorso dall'impianto, se infezione verificata per via ematogena, a prescindere dall'agente batterico, se il paziente è in buone condizioni mediche

Immagine MRI ideale di persona candidata a riparazione del tendine sovraspinato

- ☐ rottura del tendine sovraspinato con retrazione superiore a 3 centimetri
- ☐ rottura del tendine del sovraspinato con ipotrofia del muscolo omonimo
- ☐ rottura associata del tendine del sottoscapolare
- ☐ rottura del tendine del sovraspinato con artrosi glenoomerale
- ☐ osteolisi della testa omerale
- ☐ nessuna delle precedenti

PROVA SCRITTA N 3 ALLEGATO N 3

Pseudoartrosi in esiti di sintesi: fattori da considerare

- ☐ Infezione
- ☐ Vascolarizzazione
- ☐ Meccanica
- ☐ Biologia del paziente
- ☐ Tutte le precedenti

DAIR (debridement, antibiotics, irrigation, and retention) per il trattamento delle infezioni periprotesiche

- ☐ è concetto superato del tutto
- ☐ può essere considerato se infezione immediatamente postintervento, agente batterico agevolmente trattabile e paziente in buone condizioni mediche
- ☐ può essere considerato indipendentemente dal tempo trascorso dall'impianto, se infezione verificata per via ematogena, a prescindere dall'agente batterico, se il paziente è in buone condizioni mediche

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- ☐ rottura del tendine del sovraspinato con artrosi glenoomerale
- ☐ osteolisi della testa omerale
- ☐ nessuna delle precedenti

Finestre di opportunità per il trattamento di un paziente politraumatizzato

- ☐ giorno 1= damage control oppure early total care
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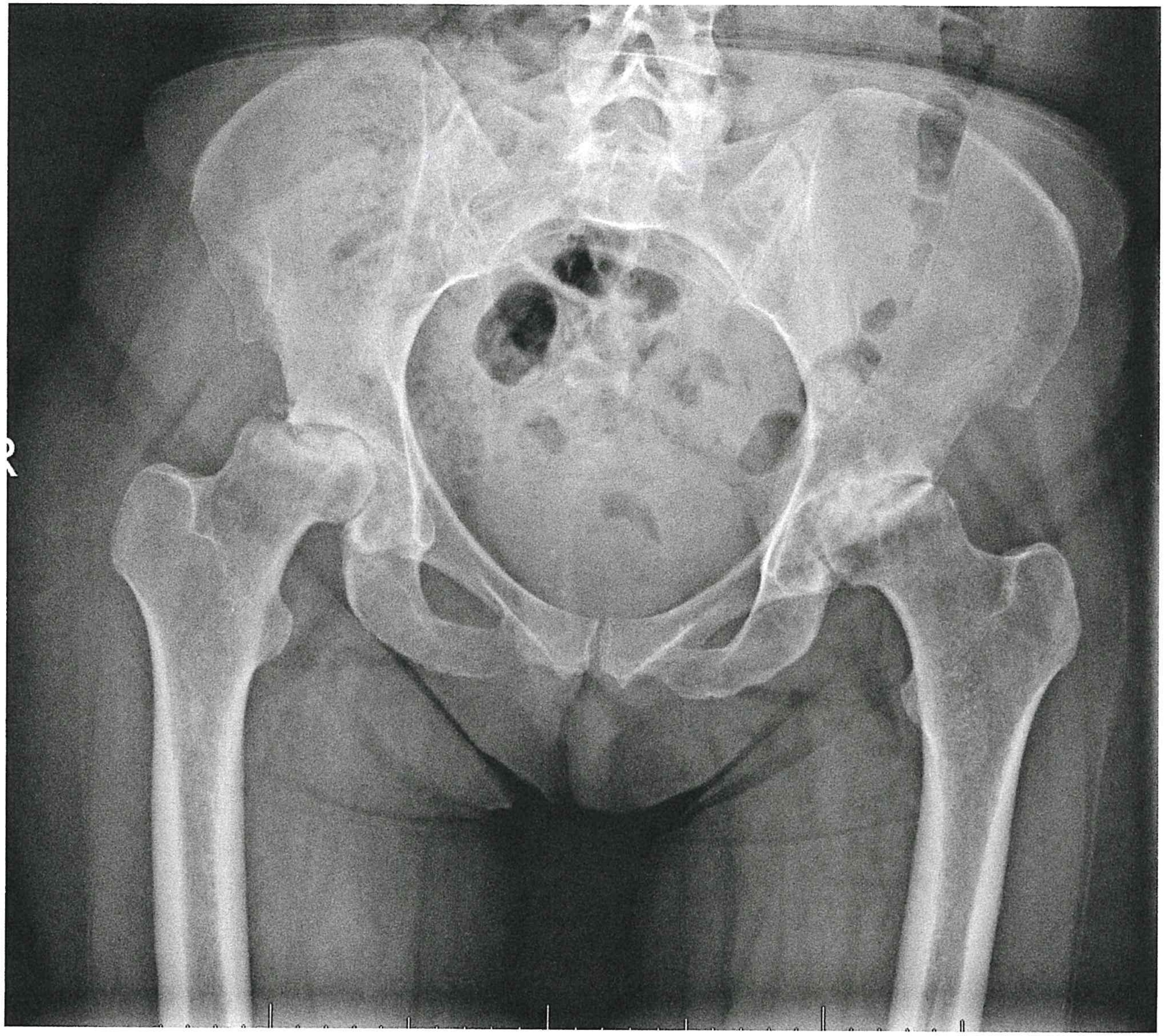
- ☐ giorno 1= damage control oppure early total care
giorni 2-4= chirurgia restituiva definitiva
giorni 5-10= solo medicazioni
giorni 11-21= chirurgia sostitutiva e correttiva
dopo il giorno 21= nessun tipo di chirurgia
- ☐ più appropriato eseguire sempre ETC: early total care
- ☐ più appropriato considerare EAC: early appropriate care.

PROVA PRATICA N 1

ALLEGATO N 4



Donna, 44 anni.
Assume methotrexate e cortisonici per artrite reumatoide.

-classificazione
-accertamenti
-prognosi
-soluzioni.

ALLEGATO N 3

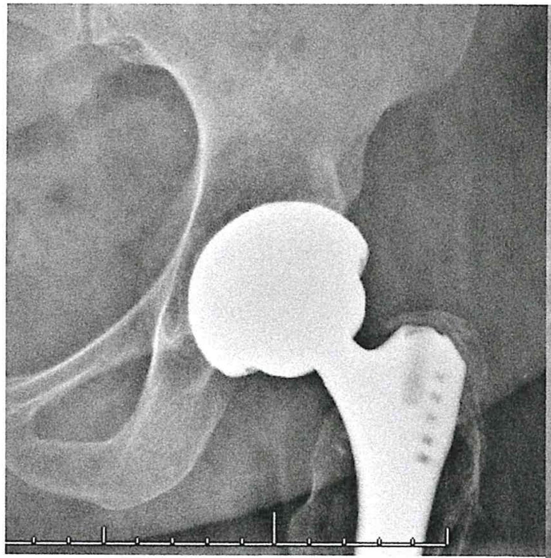
PROVA PRATICA N 2

Bambina, 7 anni.
Non assume terapie.

- -classificazione
- -accertamenti
- -prognosi
- -soluzioni.

ALLEGATO N 6

PROVA PRATICA N 3



2018 2021

Donna, 70 anni.
Non assume terapie.
-classificazione
-accertamenti
-prognosi
-soluzioni.

PROVA ORALE N 1

Acta Biomed 2021; Vol. 92, Supplement 3: e2021012 DOI: 10.23750/abm.v92iS3.11714

CASE REPORT

Intramedullary cortical fragment in tibial nailing: push it, remove it or ignore it?

Branca Vergano Luigi, Prezioso Vito, Monesi Mauro
Ospedale M. Bufalini, Cesena (FC)

Abstract
Intramedullary nailing of long bones is a safe procedure, with excellent long-term results. Even in apparently simple fractures, many complications may arise. Incarceration of a cortical fragment in the medullary canal is a fearsome situation, which may lead to severe complications and, consequently, poor outcomes. The surgeon should be aware of this risk and, after careful analysis of the pre-operative imaging, must remove or, at least, disengage the fragment from the medullary canal. (www.actabiomedica.it)

Key words: intramedullary cortical fragment, nailing, incarcerated free fragment

Introduction

Intramedullary nailing is the gold standard for many femoral and tibial fractures involving the shaft, the metaphysis or, in some cases, even fractures with limited intra-articular involvement. Even when treating cases that look simple, many intraoperative and postoperative complications may occur (1). In any fracture pattern, and especially those that are multi-fragmentary, complications due to free cortical fragments, which are incarcerated in the medullary canal, are reported in the literature (1-8). The cortical fragment can be entrapped in the proximal or distal segment, as a consequence of the injury or after guidewire/reamer insertion. This may lead to a variety of consequences: from impassable guidewire, reamers or nail, to intra-articular penetration of the fragment or of the guidewire, from iatrogenic fractures to malreduction of the fracture (if the fragment acts as a blocking screw). For these reasons, when planning to nail a femur or a tibia, high attention should be paid to these free fragments, so as to anticipate the potential operative difficulty that may be encountered during closed nailing of the fracture. We report two cases of tibial nailing for fractures with intramedullary cortical fragments.

Case reports

Case number 1

Z.M., 34-year-old male, was referred to our hospital following a motor vehicle accident. After the primary and secondary surveys, he was hospitalized in our department, diagnosed with an open fracture (G-A grade II) of the right tibia and fibula (fig. 1a). He was operated on the same day of debridement and irrigation of the wound and external fixation of the tibia. The wound was closed primarily. The following day, a CT scan of the leg was performed to better define the fracture pattern. A cortical fragment was found inside the medullary canal (fig. 1b), in the distal fragment; moreover, a fracture line of the posterior malleolus was noted (fig. 1c). After three days, the patient was scheduled for ex-fix removal and intramedullary nailing of the tibia; the intent was to address the posterior malleolus by percutaneous screws fixation after nailing. The patient was placed supine on a radiolucent table, with the knee flexed on a support for nailing via an infrapatellar approach. After preparation of the proximal tibia with an appropriate entry reamer, the guidewire was progressed to the distal segment, bypassing the free cortical fragment. During reaming, the free corti-

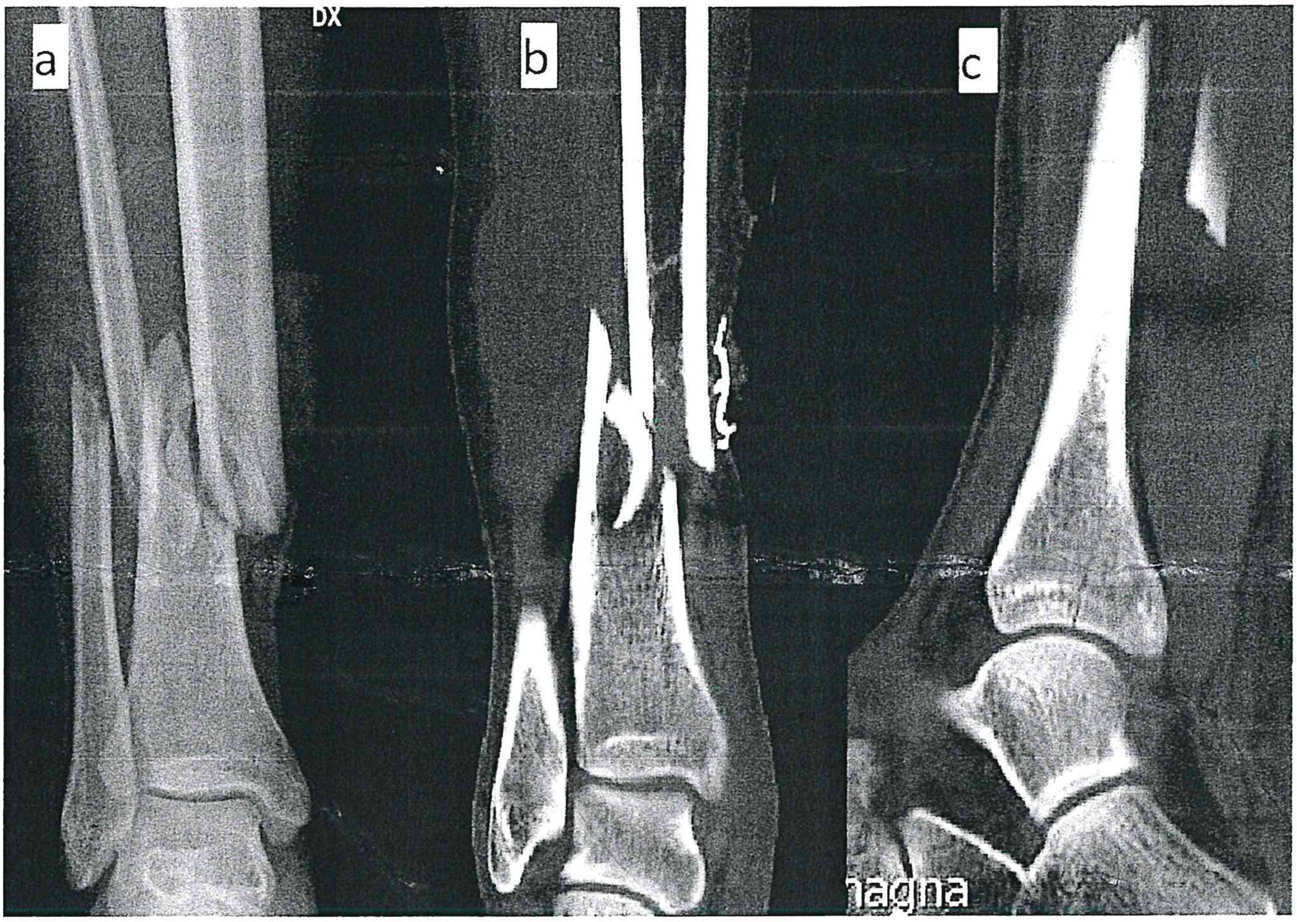


Figure 1. case number 1. a: pre-operative X-rays. b: pre-operative CT scan. The free cortical fragment incarcerated in the medullary canal is evident. c: fracture of the posterior malleolus

cal fragment was pushed down towards the epiphysis. The fragment then acted as a wedge through the distal fracture line, with consequent displacement of the posterior malleolus. Attempts to remove the fragment with a small medial incision were made, though unsuccessfully (fig. 2a). Therefore, the surgeon decided to proceed with tibial nailing, locking the nail both proximally and distally. After skin closure, the patient was placed in a prone position, and a posterolateral approach to the ankle was performed. The free fragment was removed and the fracture of the posterior malleolus was reduced and fixed with a posterior antiglide plate (fig. 2b). No complications were observed postoperatively. The patient was allowed to walk with crutches with partial weight-bearing on the right foot. The patient was encouraged to actively move the ankle and knee. Follow-up, with clinical examination and X-rays, took place after one, two and four months. At the last follow-up, the patient had regained full motion of the knee and ankle and the fracture was considered healed (fig. 2c). A one-year follow-up was prescribed but the patient did not show up for the medical appointment.

Case number 2

L. M., 27-year-old male, sustained a trauma to his left tibia while skiing. He was admitted to the emergency department of the local hospital, where he was diagnosed with a closed fracture of the left tibia and fibula. He was then splinted and discharged, with the recommendation to refer to his local hospital. The patient was admitted to our department the day after, and the operation was scheduled for the following

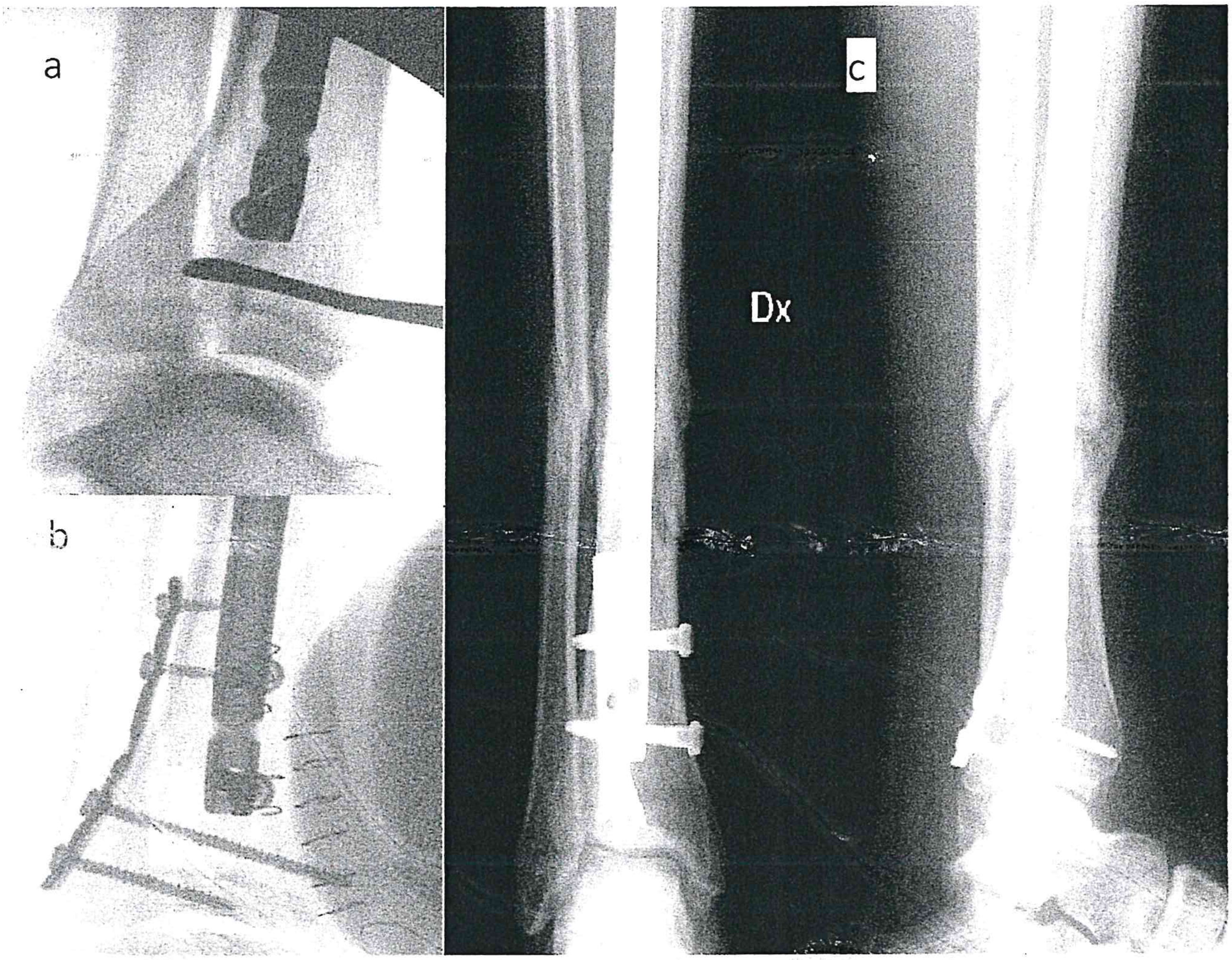


Figure 2. Case number 1. a: percutaneous attempt to remove the free fragment with a freer. b: fixation of the posterior malleolus with plate and screws, after removal of the fragment. c: final X-rays of the healed fracture

day. While planning the operation, an X-ray revealed a free cortical fragment inside the medullary canal (fig. 3a). The patient was positioned on a radiolucent table, with the knee semi-extended, to perform a suprapatellar nailing of the tibia. After reaming of the proximal tibia, the guidewire was easily passed through the fracture (fig. 3b), beside the cortical fragment. A first attempt to remove the free fragment with the hook was made (fig. 3c), though unsuccessfully. It was then decided to proceed with reaming, pushing the fragment distally. During the last reaming, the fragment laid in the centre of the medullary canal, deviating the trajectory of the ream (fig. 3d), and thus the one of the future nail. For this reason, the surgeon decided to remove the fragment. Given the impossibility to grasp the fragment through the medullary canal, the surgeon performed a little incision on the medial side of the leg and removed the fragment with a pituitary rongeur (fig. 3e - 4). The nail was then inserted and locked. The patient was allowed full weight-bearing from the following day. After the routine follow-up examinations, at 6 months the patient had regained full range of movement of the knee and ankle, and the fracture had healed completely (fig. 5).

Discussion and conclusions

Eastman (1) reports, in his institution, the prevalence of an incarcerated fragment to be 2 out of 80

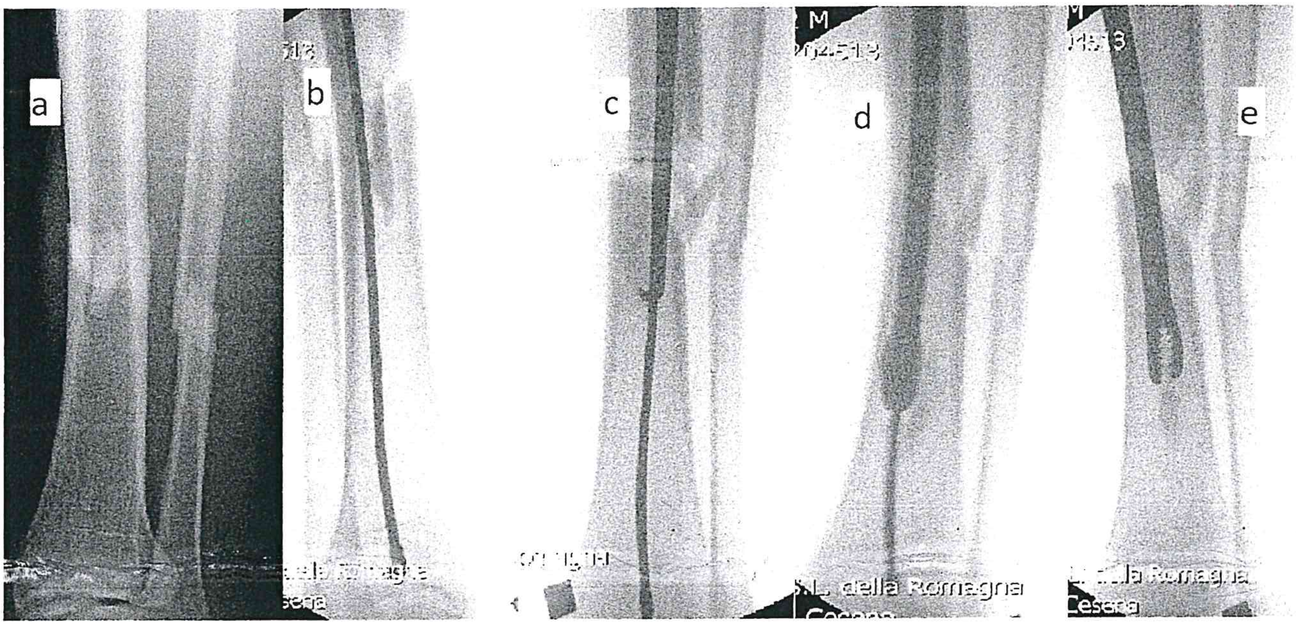


Figure 3. Case number 2. a: pre-operative X-rays, with evidence of a cortical fragment across the fracture. b: progression of the guidewire behind the fragment. c: a hook is used in trying to remove the fragment. d: the reamer pushed the fragment distally, with consequent eccentric reaming. e: the rongeur is grasping the fragment, for extraction

(2.5%) for femur fractures and 1 out of 70 (1.4%) for tibia fractures. These numbers show that the problem of free cortical fragments in the medullary canal is rare but not exceptional. Usually, the first attempts aim to dislodge the fragment with the guidewire or with the reamer to allow a safe and right trajectory of the nail. If this cannot be obtained, many complications, as described in the literature, may arise:

- in tibial nailing, the free fragment may be driven through the plafond into the ankle joint (6);
- the incarceration of a fragment of bone between the guidewire and a tibial nail may prevent smooth sliding of the nail on the guidewire when hammering the nail. This may lead to progression of the guidewire through the ankle and the tarsal bones, until it protrudes under the skin of the foot sole (5);
- similarly, an incarcerated bone fragment at the tip of a femoral nail may lead to jamming of the guidewire, and, consequently, to intraarticular progression of the wire inside the knee (3);

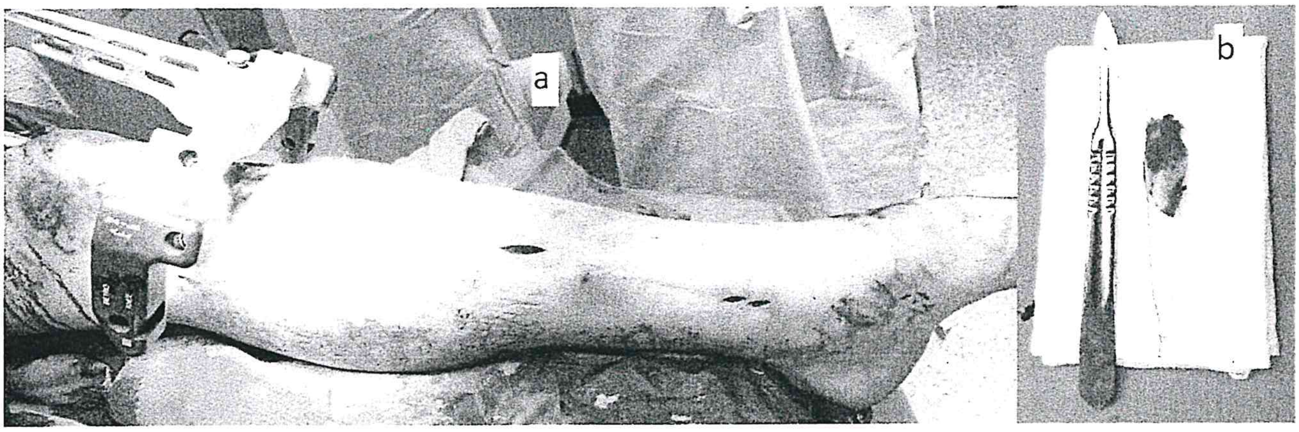


Figure 4. Case number 2. a: clinical picture of the leg, with the small medial incision at the middle third. b: the fragment extracted

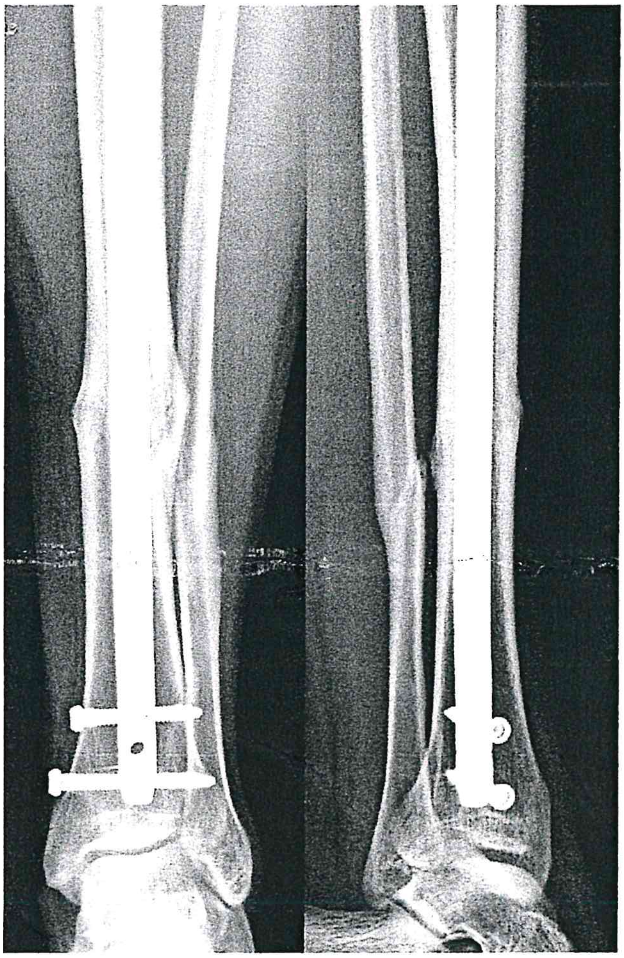


Figure 5. Case number 5. Tibial fracture healed

- in tibia and femur, if the fragment is pushed between the nail and the cortex, eccentric reaming can lead to iatrogenic fracture or, if the nail is inserted in any way, to malreduction of the fracture (2, 7);

Once the surgeon has decided to remove the free fragment, many techniques may be employed to address it:

- a long, narrow, endoscopic grasper can be used through the proximal skin incision, passing inside the medullary canal, to catch the fragment. Only during femoral nailing, if the shape of the fragment does not allow its proximal extraction, it can be released into the soft tissues adjacent to the fracture site (1);
- an extraction hook can be utilized to grasp or mobilize the fragment (4);
- in cases where the aforementioned percutaneous attempts in removing the fragment are in vain or useless, a solution can be, as in our case number 2 and as reported by Salamon (7) in tibia fractures, a formal open removal of the fragment, with a small incision on the medial side of the leg at the level of the fracture.

Even before a "simple" femoral or tibial nailing, a careful visualization of the X-ray (or CT scan, if available) is mandatory during the surgical planning, to detect whether a free fragment is obtruding the medullary canal. The risk of incarcerated fragment is high especially in a comminuted shaft fracture (3).

If the guidewire cannot be passed easily across a reduced fracture, any attempt to force the wire should be avoided. Suspicion of an incarcerated fragment should suggest that the surgeon re-analyse the preoperative X-rays / CT scan or re-check the fracture with several fluoroscopy views (7).

Usually, nailing a shaft fracture is a close procedure, and the key for a successful operation is to keep the soft tissues around the fracture intact. However, in case of need, such as the necessity to remove a free fragment from inside the canal, a small skin incision is mandatory and, with gentle handling of the soft tissues, the infection risk can be minimized.

In conclusion, if a free fragment in the medullary canal is noted during nailing, it must absolutely not be ignored.

Conflicts of interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

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ORIGINAL ARTICLE

Bone and joint infections in adults: a comprehensive classification proposal

Carlo Luca Romanò · Delia Romanò · Nicola Logoluso · Lorenzo Drago

Received: 14 January 2011 / Accepted: 31 March 2011 / Published online: 14 April 2011

Abstract
Introduction and methods Ten currently available classifications were tested for their ability to describe a continuous cohort of 300 adult patients affected by bone and joint infections. Each classification only focused, on the average, on 1.3±0.4 features of a single clinical condition (osteomyelitis, implant-related infections, or septic arthritis), being able to classify 34.8±24.7% of the patients, while a comprehensive classification system could describe all the patients considered in the study.
Result and conclusion A comprehensive classification system permits more accurate classification of bone and joint infections in adults than any single classification available and may serve for didactic, scientific, and clinical purposes.

Keywords Bone and joint infections (BJIs) · Osteomyelitis · Implant-related infection · Septic arthritis · Joint infection

Introduction

The term osteomyelitis was first used by the French surgeon Edouard Chassaignac in 1852 [1], who defined the disease as an inflammatory process accompanied by bone destruction and caused by an infecting microorganism.

In the past, osteomyelitis infections were mainly the results of direct bacterial penetration into the bone or adjacent tissues, through soft tissue lesions secondary to low-energy traumas (wounds, falls, punctures, bites, etc.) or to hematogenous spreading of the microorganisms from septic foci localized in other organs and apparatus. While those mechanisms of bacterial colonization of the bone tissue have not disappeared, especially in the industrialized world and during the last century, a progressive increase of bone and joint infections (BJIs) due to high-energy traumas (wars, traffic, sports, etc.) or secondary to surgical procedures has been observed. Besides this, more and more osteomyelitis and septic arthritis today are found to be causally related with dismetabolisms (diabetes, renal insufficiency, etc.), peripheral vasculopathies and neuropathies, life habits (smoking, drug, or alcohol abuse), inherited or acquired immunodeficiencies, and advanced age. On the other hand, over the past decades, a tremendous progress in the knowledge and treatment of the different types of BJIs has been made, and many factors that account for the occurrence and persistence of this disease have now been identified [2, 3]. New operative techniques and a variety of antimicrobials with different spectrums of activity against specific pathogens have also been developed and their use recommended for specific clinical presentation of BJIs.

In this complex panorama, a single universally accepted classification system of BJIs is not available [4]. In fact, even the most commonly used classifications only focus on one or few aspects (etiology, anatomo-pathology, host type, etc.) of single specific pathological conditions, like osteomyelitis [5–8], periprosthetic infection [9, 10], or septic arthritis [11], being thus unable to represent any given patient affected by BJIs.

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The aim of the present paper is to discuss, in the light of the available literature and classifications, the most relevant items that are required to characterize BJIs in adults and to propose a unique, comprehensive classification of BJIs.

Methods

We searched MEDLINE, EMBASE, and the principal Internet search engines (www.google.com, www.yahoo.com, www.ask.com, www.bing.com) for general keywords such as "classification," "staging," "infection," "bone," "joint," "osteomyelitis," both isolated or in combination, from 1970 until present. We also included previous classification proposals published in the Italian literature and here briefly summarized in English. The reference list of studies which met the inclusion criteria was further screened for inclusion of manuscripts which could have been omitted from the initial screening process.

To further understand the specificity of the available retrieved classifications, they were divided according to the main object basis of classification and the classified items.

The retrieved classifications and a new comprehensive classification system were then tested and compared for the ability to describe the clinical condition of a continuous cohort of 300 adult patients affected by bone and joint infections who were treated surgically in our department during years 2008–2009.

Results

The review of the available literature confirms BJIs as a complex group of diseases, for which various classification systems have emerged in the past four decades. A total of ten classifications dealing with a clinical manifestation of BJIs were retrieved. A summary of the content of each of them is reported in Table 1.

The average age of all the classification systems, from the first year of publication to present, is 21.4±11.6 years (maximum, 40; minimum, 4 years). Seven out of ten classifications were published more than 20 years ago.

The two main variables studied by the available classification systems of BJIs are: (1) the type of nosological entity (osteomyelitis, implant-related infections, and septic arthritis) and (2) a particular feature (item) of that nosological entity.

Considering the ten classifications retrieved, we may observe that five classification systems are focused only on osteomyelitis, three on implant-related infections, one on septic arthritis, while one classification includes all the three nosological entities, even if dealing with a single peculiar aspect of the infection (bone defects).

Overall, seven items that characterize BJIs have been described by one or more classification system: clinical presentation, etiopathogenesis, anatomo-pathology, host, microorganism, bone defect, and soft tissues. The mean number of items categorized by any single classification is 1.3±0.4 (range, 1 to 2).

A brief description of the seven items, the way they are classified by the respective systems, and some more data concerning their relevance with regard to BJIs are provided below.

Clinical presentation

Historically, osteomyelitis has been categorized as acute, subacute, or chronic based on the time of disease onset (i.e., occurrence of infection or injury). The duration of symptoms of infection is in fact associated with peculiar anatomo-pathological findings and clinical and diagnostic features, and influences the therapeutic decisions [10, 12–15].

Acute osteomyelitis is diagnosed within 2 weeks after disease onset, subacute osteomyelitis within one to several months, and chronic osteomyelitis after a few months [12, 16]. Acute osteomyelitis occurs predominantly in children, with the metaphysis of long bones the most common location. Patients usually present within several days to 1 week after the onset of symptoms. In addition to local signs of inflammation and infection, patients have signs of systemic illness, including fever, irritability, and lethargy. Typical clinical findings include tenderness over the involved bone and decreased range of motion in adjacent joints. The subacute and chronic forms of osteomyelitis usually occur in adults. Generally, these bone infections are secondary to an open wound, most often an open injury to bone and surrounding soft tissue. Localized bone pain, erythema, and drainage around the affected area are frequently present. The cardinal signs of subacute and chronic osteomyelitis include draining sinus tracts, deformity, instability and local signs of impaired vascularity, range of motion, and neurologic status.

Analogously, periprosthetic infections have been classified according to time of onset after surgery as early, delayed, or late. Early manifestation is generally defined as the appearance of the first signs and symptoms of infection during the first 4–12 weeks post-surgery, according to different authors. Delayed manifestation is defined as an infection in which the first signs and symptoms appear between 3 months and 2 years post-surgery, and late manifestation is defined as the appearance of the first signs and symptoms of infection >2 years post-surgery [10, 17, 18].

Table 1 Classifications of bone and joint infections published in the last four decades

Authors	Year of first publication	Main object of classification	Classified items
Waldvogel et al.	1970	Osteomyelitis	Duration
			Acute
			Chronic
			Etiopathogenesis
			Hematogenous osteomyelitis
			Osteomyelitis secondary to contiguous focus of infection
			No generalized vascular disease
			Generalized vascular disease
Ger R.	1977	Osteomyelitis	Soft tissue
			Type I, simple sinus
			Type II, chronic superficial ulcer
			Type III, multiple sinuses
			Type IV, multiple skin-lined sinuses
Cierny and Mader	1984	Long bone osteomyelitis	Anatomo-pathological
			Stage 1, medullary osteomyelitis
			Stage 2, superficial osteomyelitis
			Stage 3, localized osteomyelitis
			Stage 4, diffuse osteomyelitis
			Host
			Type A, normal
			Type B, compromised (local and/or systematic)
			Type C, treatment worse than the disease
Kelly et al.	1984	Osteomyelitis	Etiopathogenesis
			Hematogenous osteomyelitis
			Posttraumatic (united fracture)
			Posttraumatic (nonunited fracture)
			Post-surgical
			Anatomo-pathological
			Type I, open, without evidence of bone infection
			Type II, circumferential, cortical, and endosteal infection
			Type III, cortical and endosteal infection associated with segmental bone
Gächter A.	1985	Septic arthritis (knee)	Anatomo-pathological
			Stage I, opacity of fluid, redness of the synovial membrane, no radiographic changes
			Stage II, severe inflammation, fibrinous deposition, pus, no radiological changes
			Stage III, thickening of the synovial membrane, compartment formation, no radiological changes
			Stage IV, aggressive pannus with infiltration of the cartilage, undermining the cartilage, radiological signs of subchondral osteolysis, possible osseous erosions, and cysts
Gordon et al.	1988	Osteomyelitis (tibia)	Bone defect
			Type A, tibial defects and nonunions without significant segmental loss
			Type B, tibial defects of <3 cm, intact fibula
			Type C, tibial defects of >3 cm, no intact fibula

Table 1 (continued)

Authors	Year of first publication	Main object of classification	Classified items
McPherson et al.	2002	Implant-related infections (hip prosthesis)	Duration I, early postoperative (<4 weeks from surgery) II, hematogenous (<4 weeks duration) III, late chronic (>4 weeks duration) Host Type A, uncompromised Type B, compromised (one to two compromising factors) Type C, significantly compromised (more than two compromising factors)
Romanò et al.	2006	Osteomyelitis Septic arthritis Implant-related infections	Bone defect Type 1, cavitary defect Type 2, epiphyseal defect Type 3, segmental defect
Romanò et al.	2006	Implant-related infections (osteosynthesis)	Anatomo-pathological Type I, stable osteosynthesis, with callus progression Type II, stable osteosynthesis, with scarce or absent callus progression Type III, no callus formation and unstable osteosynthesis

Etiopathogenesis

Etiopathogenesis of BJIs has a clear importance as regards the natural history, epidemiology, diagnostic, and treatment modalities.

The Waldvogel classification system [8, 12] divides osteomyelitis not only on the basis of duration but also according to the pathogenesis into: secondary to a contiguous focus (trauma, surgery, or insertion of a joint prosthesis), secondary to vascular insufficiency, and hematogenous.

Hematogenous osteomyelitis is predominantly encountered in the pediatric population. In children, hematogenous infection usually affects the long bones, while in adults, the lesion is usually located in the thoracic or lumbar vertebrae. Osteomyelitis secondary to a contiguous focus of infection can derive either from a direct infection of bone from a source outside the body (e.g., soft tissue trauma, open fracture, or surgery) or from the continuous spread of infection from an ulceration, adjacent focus (e.g., soft tissue infection, dental abscess, or decubitus ulcer). Osteomyelitis associated with vascular insufficiency as described by Waldvogel was mainly due to diabetes (diabetic foot); however, it can be caused by atherosclerosis, vasculitis, etc.

Kelly proposed a similar etiopathogenetic classification of osteomyelitis in the adult, divided into four categories: hematogenous, osteomyelitis in a united fracture (fracture with union), osteomyelitis in a nonunion fracture (fracture with nonunion), and postoperative osteomyelitis without fracture [19]. Kelly's classification system emphasized the etiology of the infection and its relationship to fracture healing.

More recently, a pathogenetic role of neuropathy has been demonstrated [20], and this component should probably be included in a modern classification of osteomyelitis based on etiopathogenesis.

On the other hand, post-surgical infections have been differentiated, in the last years, on the basis of the presence/absence of implanted materials. Implant-related infections are probably the most relevant burden of BJIs in the developed countries [21, 22] and possess peculiar pathogenetic, diagnostic, and therapeutic features that clearly differentiate them from other conditions in which no foreign material is present. Implant-related infections are in fact characterized by challenging diagnosis and treatment, due to the particular ability of bacteria to adhere to the surface of the implanted hardware. It is largely demonstrated how bacteria, after adhering to a surface, become able to produce a polysaccharidic biofilm that protects the pathogens from immunological response and antibiotic activity and make them behave like a multicellular organism [2, 3, 22, 23]. The presence of biofilm usually makes it necessary to remove the implant to obtain the healing from infection. Considering implant-related infections, a further difference may be retrieved between permanently implanted materials (e.g., total joint prosthesis) and temporary implant materials (e.g., osteosynthesis, nails, plates, etc.). While, in fact, a prosthesis has been designed to stay in the body forever and the removal of an infected prosthesis determines a loss of function of the joint, osteosynthesis and fixation materials are intended for a temporary use and only needed until bone healing takes place.

To our knowledge, there are no published classifications of infections after osteosynthesis in the English literature. Few years ago, we proposed a simple classification system ("ICS Classification," from the acronym of Infection, Callus, Stability) [24] based on the observation that infection may slow callus formation but does not prevent, in itself, bone healing [25–27]; according to this classification, three conditions can be distinguished:

- Type I: infection in the presence of a stable osteosynthesis, with callus progression at X-ray examinations. The treatment in these cases may be conservative, controlling the infection with medico-surgical procedures, allowing until bone healing. Hardware removal is then performed after fracture healing.
- Type II: presence of infection in a stable osteosynthesis, with scarce or absent callus progression. In those cases, the synthesis can be maintained, controlling the infection as for type I, accelerating bone healing through physical stimulation (low-intensity pulsed ultrasound [28], electromagnetic fields, etc.), biological factors (bone morphogenetic protein, platelet rich plasma, etc.), and limited surgical procedures (e.g., dinamization).
- Type III: infection, no callus formation, and unstable osteosynthesis. In these cases, synthesis removal and change of the fixation device are required.

Anatomo-pathological findings

Anatomo-pathological aspects of each BJI are among the most important determinants of the treatment strategy and of the success rate. The simple site of infection—that we may here divide into long bones, joints, rachis, hand, foot—strongly determines the treatment choice, due to the relevant difference in vascularity, soft tissue coverage, function, and possible treatment options. For this reason, a clear definition of the localization BJIs in various patients should be mandatory.

In this regard, however, we only found more detailed anatomo-pathological classifications of BJIs for osteomyelitis of the long bones and for septic arthritis of the knee.

Weiland [29] defined chronic osteomyelitis as a wound with exposed bone, positive bone cultures, and drainage for <6 months. A similar wound with drainage of less than 6 months was not considered to be a site of chronic osteomyelitis. He further divided the infection on the basis of soft tissue and the location of bone involved. Type I osteomyelitis was defined as open, exposed bone without evidence of osseous infection but with evidence of soft tissue infection. Type II osteomyelitis showed circumferential, cortical, and endosteal infection. The radiographs demonstrated a diffuse inflammatory response, increased bone density, and spindle-shaped sclerotic thickening of the cortex. Other radiographic findings included areas of bony resorption and often a sequestrum with a surrounding involucrum. Type III osteomyelitis revealed cortical and endosteal infection associated with a segmental bone defect.

The Cierny–Mader classification [5–7, 30] is a well-known clinical classification based on anatomic, clinical, and radiologic features. From the anatomo-pathological point of view, it characterizes osteomyelitis as being in one of four anatomic stages. In stage 1, or medullary, osteomyelitis is confined to the medullary cavity of the bone. Stage 2, or superficial, osteomyelitis involves only the cortical bone and most often originates from a direct inoculation or a contiguous focus infection. Stage 3, or localized, osteomyelitis usually involves both cortical and medullary bones. In this stage, the bone remains stable, and the infectious process does not involve the entire bone diameter. Stage 4, or diffuse, osteomyelitis involves the entire thickness of the bone, with loss of stability, as in infected nonunion. The authors showed how each stage may require an appropriate and different treatment strategy, and this classification is then useful for decision making.

Cierny and DiPasquale tried to adjust the Cierny–Mader classification system for osteomyelitis in adult patients also for the classification of periprosthetic total joint infections [9]. In this system, prosthetic joint infections are entered as anatomic types of the disease: early and superficial 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.

Septic arthritis has also been classified according to their morphological aspect. The classification system, first described by Gächter [11] for the knee, seems applicable also to other joints [31]. This classification system consists of four stages and combines intra-articular findings in the soft tissues as well as radiological alterations of the infected joint:

- 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. According to the Author, infections classified up to stage III can be arthroscopically treated, whereas stage IV requires open revision surgery.

Host type

Host is one of the most relevant factors both concerning susceptibility to develop BJIs and prognosis of the disease.

We have already mentioned how acute, subacute, and chronic osteomyelitis occur with different frequency in different ages. Age is not only connected with the occurrence of hematogenous infection, but extremes of age also play a role in the immunological response and prognosis of BJIs [32].

The Cierny–Mader system was the first to include host type classification [6, 30, 33]. According to this classification, the A-hosts are patients without systemic or local compromising factors, B-hosts are affected by one or more local and/or systemic compromising factors, and C-hosts are patients so severely compromised that the radical surgical treatment necessary would have an unacceptable risk–benefit ratio. One shortfall of this system is that, by definition, the C-host category is a subjective evaluation, since the indication to a given surgical procedure is influenced not only by the patient's comorbidities, but, to a great extent, also by hospital facilities, surgeon's skill and self-confidence, previous experience, etc.

In this regard, the most recent classification proposed by McPherson and co-workers [30] provides a more clear and standardized system for host definition that the author proposes a part of their classification of periprosthetic hip infection. Compromising factors are similar to those proposed by Cierny–Mader; however, according to the system from McPherson, patients are divided in A, uncompromised, normal hosts; in B, compromised hosts, with one to two local and/or systemic compromising factors; in C, significant compromise, with more than two compromising factors. This definition is obviously more reproducible and not influenced by the treatment indication.

Microorganism

The correct definition of the infecting agent and its antibiotic resistance drives the medical approach, correlates with the prognosis and to the natural history of each BJI. Ure et 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) [34].

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 antibiotic-resistant bacteria [35]. 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.

Depending on the causative pathogen organism, infections can be divided into bacterial, mycotic, and fungal ones. Bacterial infections can be further classified as gram-positive or gram-negative and mono- or multibacterial. Culture-negative infections pose special problems with regard to diagnosis, treatment choice, and patient compliance.

The specific microorganism(s) isolated from patients with bacterial osteomyelitis is often associated with the age of the patient or the clinical scenario. *Staphylococcus aureus* is implicated in most cases of acute hematogenous osteomyelitis and is responsible for up to 90% of cases in otherwise healthy children. *Staphylococcus epidermidis*, *S. aureus*, *Pseudomonas aeruginosa*, *Serratia marcescens*, and *Escherichia coli* are commonly isolated in patients with chronic osteomyelitis or implant-related infections.

Fungal infections are rare but commonly found in immunosuppressive patients and associated with complications and infection persistence [36]. 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.

Bone defect

Bone defects are a common finding in osteoarticular infections. Bone loss may be the result of the infection per se, of previous trauma or surgery, of hardware loosening and removal, and of the necessary surgical necrotic and infected bone debridement. Classification of bone defects is relevant to the treatment strategy, as many different therapeutic options are today available, including antibiotic-loaded biomaterials [22, 37], modular revision prosthesis, orthopedic and plastic special procedures [38–41], etc. Different classification systems have been proposed based on the site and extent of the bone defect; however, specific classifications for bone infections are remarkably few.

Different, detailed classifications have been, in fact, proposed to categorize bone defect in joint reconstruction after aseptic loosening of a joint prosthesis [42–45]. The use of these classifications may be extended to bone loss due to infection in revision surgery; however, no specific classification has been reported so far.

As to concerning long bones, Gordon [46] classified infected tibial nonunions and segmental defects on the basis of the osseous defects. Type A included tibial defects and nonunions without significant segmental loss. Type B included tibial defects of <3 cm with an intact fibula. Type C included tibial defects of >3 cm in patients whose fibula was not intact. Gordon's classification correlates with the prognosis for successful free-muscle transportation.

Few years ago, we proposed in the Italian literature a simple general classification of the bone defect that categorized bone defect [47] as follows:

- Type 1: cavitary defects. This common type of bone defect may occur in the context of a bone segment and is usually well delimited by a sclerotic bone. The volume of this defect may vary from few cubic millimeters to several cubic centimeters. The stability of the bone segment is maintained. Type 1 defects may be frequently observed in hematogenous infections, periprosthetic infections, and after osteosynthesis. They usually can be treated with local debridement and antibiotic-loaded fillers (either resorbable, like bone graft or bone substitutes, or non-resorbable, like polymethylmetacrylate) [22, 37];
- Type 2: is an epiphyseal defect. It features a total or partial bone loss at the joint level. It may be the result of a septic joint arthritis, septic osteosynthesis, or periprosthetic joint infection. The treatment usually consists of prosthetic implant, arthrodesis, arthroplasty, or amputation.
- Type 3: is a segmental bone defect. This is further divided into type 3A, when a gap between bone extremities is less than 1 cm; type 3B, when the gap is less than 3 cm and more than 1 cm; and type 3C, when the gap is more than 3 cm. Type 3 defects are, by definition, associated with a loss of bone stability. This type of defect may be retrieved in septic incomplete or nonunions, segmental bone resection after infection, etc. It may require external fixation with or without bone grafts, bone transport [48], segmental prosthesis, or vascularized bone grafts.

Soft tissues

Soft tissues play a major role in the prognosis and the treatment of BJIs, not only because bone exposition may clearly determine bone contamination, superinfection, and necrosis but also because the amount and quality of soft tissue are associated with local vascular support and tissue nutrition. To our knowledge, a systematic classification of soft tissues in BJIs has not been described.

Ger's classification system, published in 1977, addressed the physiology of the wound as it relates to osteomyelitis in a more detailed manner; his categories include: simple sinus, chronic superficial ulcer, multiple sinuses, and multiple skin-lined sinuses [49].

The "Seven-Item Comprehensive Classification System"

Most of the retrieved classifications of BJIs present a rather old age, only focus on a single clinical entity, and do not categorize more than two aspects (usually only one) of the disease under study at a time. These are, in our opinion, the main reasons why all the currently available classifications fail to provide a complete description of the vast universe of bone and joint infections that we face in the clinical practice. The way BJIs are *not* currently classified also explains how difficult it is for a common orthopedic surgeon or an infectivologist to approach this disease in a comprehensive manner and with a common vision and language.

In our review, based on the currently available classifications and on the data from the literature, we could identify at least seven items that all determine, to a different extent and with different modalities, the natural history, diagnosis, treatment, and prognosis of BJIs. The discrepancy between the number of the known relevant items and the number of those actually categorized by any single classification gives the measure of the incomplete description provided by all the existing classifications.

In fact, even considering two of the most sophisticated and recent classification systems, the one from Cierny–Mader [7, 30] and that from McPherson and co-workers [10], we may observe that they only focus on a maximum of two items and only in, respectively, osteomyelitis of the long bones and periprosthetic infections of the hip.

Our purpose, at the end of this review, was to present a comprehensive classification of BJIs. Instead of proposing a completely new classification, it seemed more appropriate, at this stage, to choose among the existing classifications the most reliable categorization of each of the seven selected items and put them into an organic classification system of the whole world of BJIs. This "Seven-Item Comprehensive Classification System (7 ICCS)" then includes the seven items described above, each one adequately categorized according to one of the existing classification, whenever possible (Table 2):

1. Clinical presentation. Our suggestion is to classify it as acute, subacute, or chronic, with the exception of implant-related infection, for which a distinction in early, delayed, and late seems more appropriate;
2. Etiopathogenesis. A modern classification should include hematogenous, dismetabolic (vasculopathic and/or neuropathic), posttraumatic, and implant-related (temporary or permanent) infections. As far as temporary implants are concerned, the ICS classification may prove useful for driving therapeutic decisions.
3. Anatomo-pathological aspects include a distinction between the site of the infection (rachis, hand, long bones, foot, and joints), while more detailed subclassifications are included for long bones, according to Cierny–Mader, and for joint infections, according to Gachter.

Table 2 The seven items of the "Seven-Item Comprehensive Classification System" of bone and joint infections

Clinical presentation		Etiopathogenesis	Anatomo-pathology	Host type/ age	Microorganism	Bone defect	Soft tissue defect
Acute	Early	Hematogenous	Rachis	$A_{a,c,i}$	Gram+	1	0
Subacute	Delayed	Vasculopathy/neuropathy	Hand	$B_{a,c,i}$	Gram−	2	cm^2 B
Chronic	Late	Trauma	Long bones	$C_{a,c,i}$	Mixed flora and/or multiresistant	3A, 3B, 3C	cm^2 B
		Temporary implant	Stage 1		Mycobacterium		
		ICS classification	Stage 2		Fungi		
		Type I	Stage 3		Negative		
		Type II	Stage 4				
		Type III	Foot				
		Permanent implant	Joint				

4. Host type and age. Concerning age, the patient should be at least divided as infants (i, <2 years of age), children (c, <14 years of age), adults (>14 years of age), while host type is better defined, in our opinion, according to the classification proposed by McPherson [10].

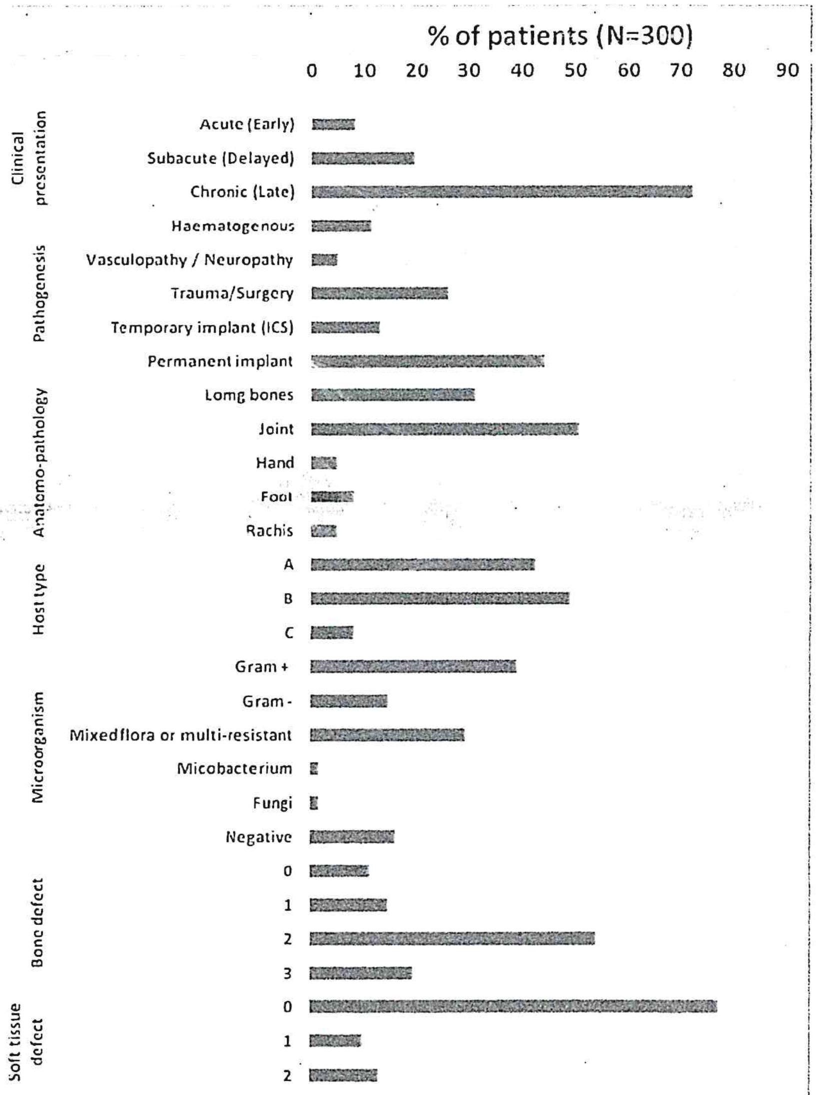

Fig. 1 Percent of patients ($N=300$) classified according to the items of the Seven-Item Comprehensive Classification System, treated consecutively for bone and joint infections in our department during the years 2008–2009

5. Microorganism(s) have been divided into gram-positive, gram-negative mycobacteria, and fungi and negative cultural examinations. A special section includes mixed flora and resistant bacteria. Each category requires a different medico-surgical approach and may have a different prognosis.
6. Bone defect is classified according to our proposal. Epiphyseal defects (type 2) may undergo a further categorization, applying the classification in use for bone loss associated with aseptic loosening of joint prosthesis [42–45].
7. Soft tissues are simply described as 0, for no soft tissue defect, number of square centimeters of the soft tissue defect, if present, with a distinction between bone exposure (B) or not.

Clinical testing of classifications

Three hundred consecutive patients, affected by BJIs and treated surgically in our department in the years 2008–2009, have been classified according to the Seven-Item Comprehensive Classification System (Fig. 1). Chronic implant-related infections of the joints in B-type hosts with gram-positive germs and no soft tissue defects predominated in our experience. However, virtually all other types of BJIs were represented, with different frequency.

Figure 2 compares the respective ability of each of the ten retrieved classifications and of the 7 ICCS to classify the same cohort of 300 patients. While the comprehensive classification system was able to classify all the patients considered in the study, each classification could only describe, on the average, 34.8±24.7% of the patients affected by BJIs.

Discussion

Different classifications have been proposed in the last four decades to describe BJIs. However, each of them only focused on one nosological entity and examined one or few items. Due to a lack of a more ample and systematic approach, it is not possible, at present, to classify all the different types of BJIs, and this was confirmed in our study with an analysis of a consecutive series of non-selected patients referred to us for the treatment of BJIs.

To our knowledge, this is the first attempt to provide a comprehensive classification of all the patients affected by BJIs; the proposed classification system is mainly based on existing classifications that have been selected to describe, in each given subject, one or more of the seven items, individuated as necessary on the basis of an accurate literature research. In this way, the 7 ICCS provides a rather complete description of all the relevant features that may be found in a given patient affected by BJIs. The proposed system is intended for didactic and scientific purposes and may be potentially used to better compare patients and clinical series; however, it should be noted that the following limitations do apply to the system:

1. There is an objective lack of a modern, accepted classification of some of the relevant items (e.g., bone loss, soft tissue defects);

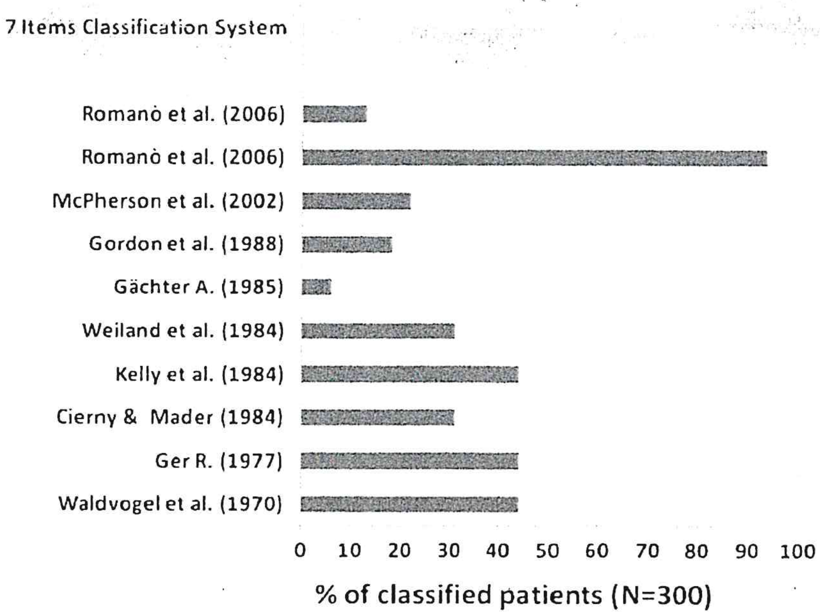

Fig. 2 Percent of patients that could be classified according to different available classifications and to the to Seven-Item Comprehensive Classification System

2. There is a lack of more specific subclassifications of some of the items. For example, infections of the hand, foot, and rachis have peculiar features, for which we decided to put apart from long bones and joint infections. However, there is no further classification of their anatomo-pathological aspect in infection, and this is probably a missing information;
3. The complexity of the system. A classification needs to be synthetic enough to be largely adopted while being sufficiently precise to serve as a basis for correct therapeutic decisions. In this case, we understand that some of the synthetic definitions of the clinical condition has been sacrificed to a more accurate description of the disease. This drawback appears as a difficult solution, given the particular nature of the infections of the skeletal system.

Competing interests The authors declare that they have no competing interests.

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Unstable total hip replacement: why? Clinical and radiological aspects

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Abstract

Introduction: Dislocation after total hip arthroplasty (THA) is the most common cause of revision hip surgery in the United States, ahead of aseptic loosening and infection, and is responsible for considerable economic cost related to frequent readmission and/or revision surgery. The aim of this article is to identify the clinical and radiological factors related to the unstable total hip replacement.

Methods: We performed a literature search to assess current strategies to define clinical and radiological characteristics of dislocation after primary THA using the PubMed platform. The characteristics related to THA instability were divided into patient related factors, implant related factors and surgeon experience.

Results: Patient-related factors for instability identified are: age; inflammatory joint disease; prior hip surgery; preoperative diagnosis; comorbidity; ASA score; presence of spino-pelvic abnormality; and neurological disability. Gender, simultaneous bilateral THA and restrictive postoperative precautions do not influence rate of THA dislocation. Implant related factors identified are: surgical approach; component malposition; femoral head size; and the use of dual-mobility or constrained solution. Surgeon experience also reduces the rate of dislocation.

Discussion: Dislocation is a major complication of THAs, and causes include patient-derived factors, surgical factors, or both. It is imperative to determine the cause of the instability via a complete patient and radiographic evaluation and to adjust the reconstruction strategy accordingly.

Keywords

Dislocation, dual mobility, instability after THA, unstable hip prosthesis

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Introduction

Dislocation after total hip arthroplasty (THA) is the most common cause of revision hip surgery in the United States, ahead of aseptic loosening and infection, and is responsible for considerable economic cost related to frequent readmission and/or revision surgery.[1] Registry data have demonstrated that dislocation is the main reason for THA revision in the first 5 years.[2] The incidence in Italy has been reported to be between 0.3% and 10% in primary THAs and up to 28% in revision THA.[3] Over 60% of patients who sustain a dislocation have multiple occurrences and over ½ require revision surgery.[4] Unstable THAs increase hospital costs by up to 300% of the cost of a primary hip arthroplasty.[5] The prevention of dislocation after primary THA requires an individualised approach to reduce the risk of instability. The aim of this article is to identify clinical and radiological factors related to unstable total hip replacement.

Methods

We performed a literature search to assess current strategies defining updated clinical and radiological factors in dislocation after primary THA using the PubMed platform. The

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search terms were "Instability" OR "Dislocation" AND "Total Hip Arthroplasty" OR "Total Hip Replacement." Relevant articles were selected, in order to obtain a summary of the causes and the clinical and radiological evaluation of instability after THA.

The factors related to THA instability were divided into patient-related factors, implant-related factors and surgeon experience.

Results

Patient-related factors

Patient-specific factors that are not related to surgery, such as advanced age or having an inflammatory joint disease increase the risk of instability, as previously demonstrated.[6] Prior hip surgery is a risk factor for dislocation following THA and appears to be associated with a higher risk of dislocation following THA. There is some evidence of a correlation between preoperative diagnosis and THA instability: patients undergoing THA for hip osteonecrosis or due to femoral neck fracture have a higher rate of postoperative instability and are twice as likely to undergo revision for instability compared to control subjects.[7]

However, instability is not a significant complication of THA for developmental dysplasia of the hip as demonstrated by 2 series that had three dislocation in total.[8,9]

Moreover, increased ASA score, neurological disability and patients with fixed spinopelvic alignment from standing to sitting position enhance the risk of dislocation.[10,11] Cerebral, spinal, neuromuscular junction, and muscle-tendon-bone integrity is required for normal hip function and stability. Common neurological conditions that may be present in patients with intractable pain requiring THA are post-stroke, Parkinson's disease (PD), acquired brain injury, cerebral palsy, and acquired spinal cord injury. A review by Queally et al.[12] recommended using constrained devices for patients who are at risk of instability, such as those with spinal injury, poliomyelitis, and cerebral palsy.

Low activity levels pre- and post-operation are a risk factor for dislocation. Lübbeke et al.[13] has shown that preoperative rehabilitation helps reduce the risk of dislocation. However, neither gender, simultaneous bilateral THA nor restrictive postoperative precautions influence rates of THA dislocation.[10] Finally, in terms of age, a retrospective analysis of 22,079 THAs showed that patients aged <50 and >70 years had a higher risk of dislocation compared to patients aged 50–69 years (bimodal distribution).[14]

Implant-related factors and surgeon experience

Dislocation rate is related to the design of implant used, approach, component positioning and the surgeon's experience. In a Canadian study of nearly 38,000 patients, surgeons who performed <35 THAs a year had a dislocation rate of 1.9% versus 1.3% for surgeons with higher numbers.[15] Posterolateral or posterior surgical approaches have been shown to be associated with higher dislocation rates than other approaches. A common surgical factor for dislocation is malposition of the acetabular cup which is that is often too vertical or not correctly anteverted. On the femoral side, excessive anteversion or retroversion of the stem can be a cause of THA instability. If the femoral component is overly anteverted, dislocation can occur when the hip is placed in extension and external rotation. If the femoral component is retroverted, posterior dislocation can occur when the hip is internally rotated. Without the use of robotics or computer-assisted navigation, the position of the patient on the operating room table is critical, as the guides used to assess the orientation of the acetabular component are based on this. Implant impingement (i.e., the femoral neck on the acetabular component or adjacent osteophytes) is another cause of THA dislocation. A reduction in femoral offset increases the probability of hip impingement and affects the efficiency of the abductors that improve the risk of dislocation.[16] According to implant factors, a larger cross-sectional diameter of the femoral neck can lead to impingement of the neck onto the acetabular component and which influences the hip range of motion (Figure 1). Femoral head size is also a factor in determining stability of the hip. Registry studies show that 22-mm and 28-mm heads have higher dislocation rates compared with 32-mm and 36-mm heads.[17] Solarino et al.[18] showed no dislocation in a series of ceramic-on-ceramic THAs performed on femoral neck fractures using 32-mm heads.

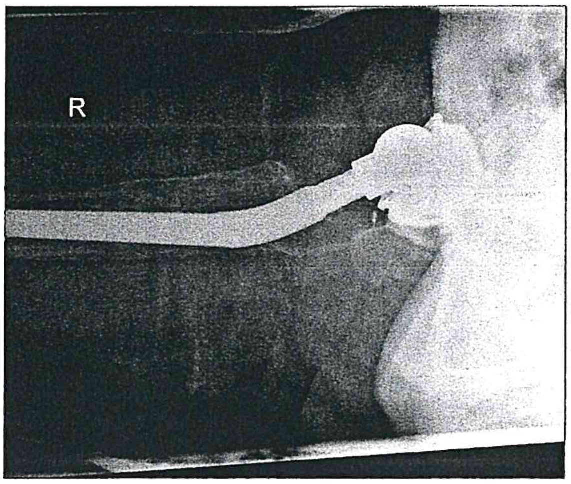

Figure 1. Posterior impingement between liner and skirted head.

The use of the elevated-rim liner continues to be controversial. Elevated-rim liners may provide additional support in the posterior-superior area preventing dislocation in adduction-internal rotation, mainly in the posterior approach to the hip joint. Their use did not show significant differences in wear rate, osteolysis, or wear-related

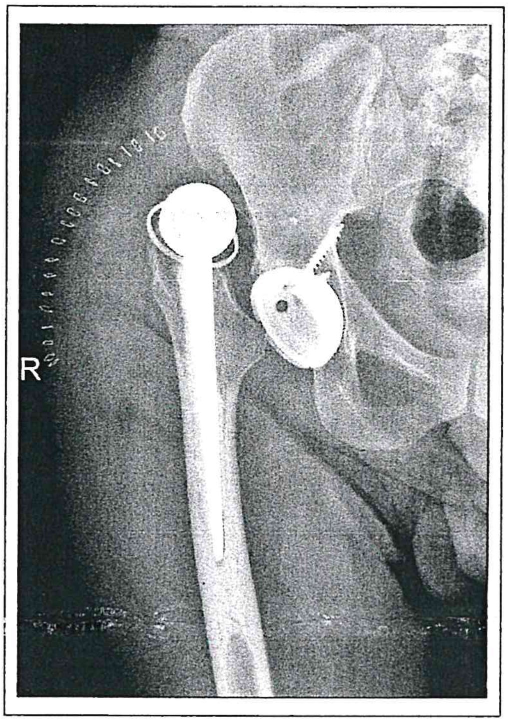

Figure 2. Early hip dislocation using constrained liner.

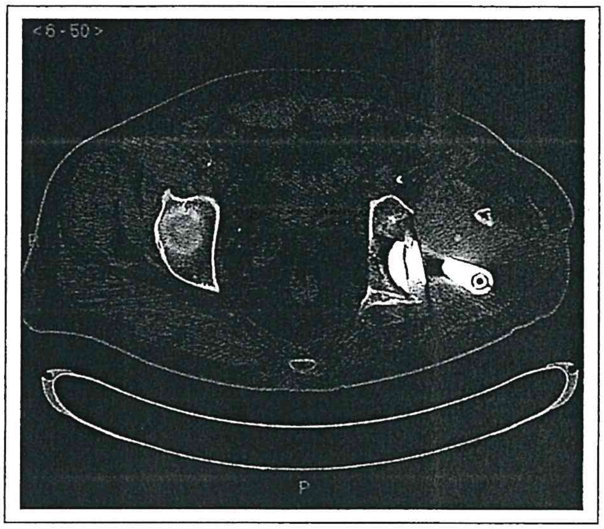

Figure 3. CT scan to evaluate the position of the components.

reoperation compared to a standard liner.[19] If not positioned correctly, the rim could create impingement with subsequent increase of risk of dislocation. The use of a dual-mobility solution is useful in high-risk patients to reduce the risk of dislocation, both in primary and revision surgery, as demonstrated by several papers.[20–23] Constrained liners are a possible solution to intraoperative instability, but some authors have reported high complication rates in both primary and revision THAs (Figure 2) and recommend reserving their use for salvage or extreme cases.[24]

Evaluation of the unstable THA

The surgical goals of primary THA are to recreate the correct hip biomechanics because any alteration may contribute to postoperative THA instability. It is important to identify whether a dislocation is early or late, as these usually occur for different reasons. Early dislocations (within 0–3 months from surgery) typically occur due to a lack of mature scar tissue, a lack of soft tissue tension, bone impingements or patient factors; dislocations that occur later in the postoperative period (after 5 years postoperatively) are primarily due to component malposition and polyethylene wear.[25]

A thorough physical examination and radiographic evaluation is essential in determining the direction and cause of the dislocation.

Radiographic assessment of the acetabular component should assess component position, the presence of osteolysis and/or component loosening. To calculate acetabular cup abduction, an anteroposterior radiographic can be used. The 'Safe zone' for acetabular component positioning is 15° ± 10° anteversion and 40° ± 10° abduction, as described by Lewinnek et al.[26] This paper has already shown considerable limitations, specifically concerning the association with spino-pelvic morbidities, but it is an important one for the topic of hip stability (see below). The version of the acetabulum can be evaluated on a cross table lateral radiograph or most accurately by computerised axial tomography. A radiographic evaluation of the femoral component should include the assessment of misalignments, and determination of the presence of osteolysis or loosening. It is important to assess the hip and femoral offset in order to determine possible impingement and soft tissue tension. The version of the femoral component can be assessed using fluoroscopy or computed tomography (CT) scan (Figure 3).[3]

The recent literature has questioned the validity of "safe zones" alone as a predictor of instability. In a recent series of almost 10,000 THAs, there were 206 dislocations of which 58% were within Lewinnek's safe zone.[27] The authors in this study recommend patient-specific targets for component positioning with good intraoperative assessment. It is clear that safe zones alone are insufficient to protect against instability. Patients with concomitant hip and spine pathology must be appropriately assessed for the presence of deformity and abnormal spinopelvic mobility when planning for THA. Adult patients with spinal deformity have been shown to have an 8% dislocation rate after THA compared to 1.5% in normal controls.[28] Spine stiffness, whether secondary to instrumented or biologic fusion (spondylosis), imparts an equally high risk of instability after THA. The dislocation rate of patients with 1–2 level and 3–7 level lumbar spinal fusion (LSF) was found to be 2.73% and 4.62% respectively, compared with 1.55% in patients without spinal fusion, demonstrating that dislocation rate increases with the number of vertebral levels fused.[29] Moreover, Malkani et al.[30] have demonstrated that patients with prior LSF undergoing THA are at significantly higher risk of dislocation and subsequent revision compared to those with THA first followed by delayed LSF. Therefore, patients with an abnormal spine-hip relation need additional preoperative screening (2 lateral spino-pelvic radiographs in the standing and seated position) to refine total hip replacement surgical planning, which may improve outcome.

It is also important to evaluate the stability assessment of the implant during the surgery. Hip adduction and hip and knee flexion at 45° mimics a lateral sleeping position and may cause subluxation. External rotation and abduction mimics stepping out of a car seat and is a risk for anterior THA dislocation. Internal rotation and hip flexion can occur when putting on footwear and is a risk for posterior dislocation. Deep flexion occurs with rising from a low seat such as a toilet and is similarly a risk for posterior dislocation. If there is impingement this should be addressed by removing osteophyte or thickened capsule, with osteotomy of anterior inferior iliac spine or increasing the offset (when possible).

Discussion

Dislocation is a major complication of THAs, and the causes include patient-derived factors, surgical factors, or both. It is imperative to determine the cause of the instability through a complete patient and radiographic evaluation (e.g., component malposition, insufficient soft tissue tension and impingement). Prevention of dislocation after primary THA requires an individualised approach to reducing the risk of instability. Recreating the native hip centre of rotation with restoration of combined offset and leg length are mandatory to reduce the risk of dislocation. Technologies that aid acetabular and femoral component implantation, like the robot or navigation system, will reduce outlying positions that may reduce dislocation risk. Good neck head ratio, large head, correct use of elevated rim liners, dual-mobility and constrained liners can all improve stability of the implant, and preoperative assessment of the patient's general characteristics and local conditions is mandatory. Component implantation in "safe zones" alone is insufficient to protect against instability. Patient-specific targets for component positioning with good intraoperative assessment are mandatory.

Many patient and surgery-related factors contribute to dislocation of THA. The role of the surgeon is to mitigate risk by recognising these factors and adjusting reconstruction strategies accordingly.

Declaration of conflicting interests

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Bone and joint infections in adults: A comprehensive classification proposal

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