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Acetabular Defects of Hip Tuberculosis: Recommended Classification and Reconstruction in Hip Arthroplasty

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Abstract

Background: This study aimed to propose a classification of acetabular defects in advanced-stage hip tuberculosis based on preoperative radiographs and intraoperative evaluation, thereby providing options for reconstructing each type of defect in hip arthroplasty. **Materials and Methods**: We conducted a prospective study with 45 patients with active hip tuberculosis at stage IV who were treated with a total hip replacement strategy. We collected the patients' acetabular defect data from preoperative radiographs and intraoperative observations. The defects were classified into types based on defect severity and reconstructive complexity. The hip replacement outcomes were evaluated at least 12 months after the operation. **Results**: The classification system includes three types: type I: localized or extensive defects inside the acetabulum, not affecting the acetabular rim, medial wall, or columns. Type II: extensive defects inside the acetabulum, affecting the acetabular rim or (and) medial wall. Type III: extensive defects inside the acetabulum, causing the medial wall and the acetabular column to lose function. Each type has a corresponding reconstruction. The outcome includes that 41/45 patients had excellent results; 3/45 patients had good results. The patients had good results due to nerve and muscle damage caused by tuberculosis not related to the acetabular defects. **Conclusion**: This is a simple, practical classification system of acetabular defects in hip tuberculosis. The outcome of hip reconstruction using this classification was excellent without any cases of dislocation or protrusion.

Keywords

Hip Tuberculosis, Hip Arthroplasty, Acetabular Defect, Classification,

Reconstruction

1. Introduction

Hip tuberculosis is the second most common skeletal tuberculosis [1]. Patients often only come to the hospital when tuberculosis of the hip has advanced to a late stage, causing difficulties in treatment and increasing hospital costs [2] [3].

Treatment of hip tuberculosis at an advanced stage includes anti-tuberculous drugs combined with orthopedic surgery. [1] Today, with the development of prosthetic hip designs and surgical techniques, hip replacement has become the optimal orthopedic surgery to help patients recover maximum joint function. Li *et al.* (2016) [4], Bi *et al.* (2014) [5], and Neogi *et al.* (2010) [6] showed that hip replacement could be performed in active tuberculosis conditions without worrying about tuberculosis reactivation. However, surgeons may face other difficulties. One of them is gross bone loss of the acetabulum due to tuberculosis infection, which may cause hip replacement failure [7] [8].

There are many classification systems for acetabulum defects, and guides for surgical restoration include D'Antonio's [9], Paprosky's [10], and Ghanem's systems [11]. However, they are only used for revision hip replacement with aseptic loosening. The morphometric and environmental properties of acetabular defects vary in hip tuberculosis. In hip tuberculosis, acetabulum is often catalysed at a weight-bearing position. Besides, the bone mineral quality may be weak at some positions such as the medial wall, acetabular roof, and acetabular column. A bone graft is restricted because osseous tissue without a vascular pedicle is favorable for tuberculosis bacilli growth [12]. Therefore, a separate classification system of tuberculous acetabular defects is necessary. It should provide a good reference in the problematic field of hip replacement.

This study aimed to propose a classification of acetabular defects in advanced-stage hip tuberculosis based on preoperative radiographs and intraoperative evaluation, thereby providing options for reconstructing each type of defect in hip arthroplasty.

2. Materials and Methods

A prospective study was conducted. We enrolled patients with active tuberculosis hips at stage IV according to the Tuli classification [1]. They were treated by a total hip replacement strategy between October 2016 and December 2020 at Vietnam's National Lung Hospital.

Inclusion criteria: patients with stage IV hip tuberculosis who were treated by hip replacement strategy at Vietnam's National Lung Hospital between October 2016 and December 2020 with a complete medical record.

Exclusion criteria:

- Patients with stage IV hip tuberculosis who had central nervous system

damage which causes hip function abnormal.

- Patients who did not agree to join the research.

The diagnosis of hip tuberculosis was based on clinical features, imaging diagnosis, and laboratory tests before surgery. The disease was confirmed postoperatively by histological examination, mycobacteria indicator tube culture (MGIT, Bactec), or molecular line probe assay to detect resistance to isoniazid and rifampicin (LPA, Hain Life Science, Germany).

Three different experts in hip arthroplasty evaluated the defects preoperatively on plain X-ray (AP and lateral view of the hip joint, AGFA, DR 400) and computed tomography scan images with 1 mm slice thickness (Siemens Somatom Emotion 16 Slice CT Scanner).

The senior surgeon who performed the replacement decided on the reconstruction implant after consulting with a panel of orthopedic surgeons. Implants from these companies were used: Dual mobile cup, Evolutis (Captive free liner, Capitol T, Capitol R); Cup augments, Chunli; Revision cementless cup cage, Chunli.

The characteristics of the acetabulum defects were collected from the patients' preoperative data and the surgical observations. Location of the defect: superior dome, medial wall, acetabular rim, anterior column, or posterior column. The defect's magnitude was determined by the diameter of the defect's circumscribed circle.

We then classified the tuberculous acetabular defects into three types with nine subtypes based on the severity of the defect and the reconstructive complexity, building up our system of tuberculous acetabular defect classification. Type 1 includes simple acetabular defects that can be replaced by a normal hemispherical cup. Type 2 are more complex acetabular ruins that require special cup designs to get stability. Type 3 includes the most complicated damages which had to use reinforcement cages to avoid cup dislocation, causing hip replacement failure.

The outcomes of hip replacement were evaluated at least 12 months after the operation according to the Harris hip score. [13] It includes four ratings: Excellent: Harris hip score 90 - 100; Good: Harris hip score 80 - 90; Fair: Harris hip score 70 - 80; Poor: Harris hip score < 70.

Statistical analysis

Data were managed and analyzed using SPSS software (version 22.0). Average and standard deviation analyses were used.

Ethical considerations

The patients were informed in detail about the study, and written informed consent was obtained. The study proposal was submitted to and approved by the IRB (No. 69/GCN/HĐĐĐNCYSH-ĐHYHN, dated March 17, 2020) of Hanoi Medical University.

3. Results

We enrolled 72 patients; 27 patients were excluded because we did not find any

proof of histology or microbiology that confirmed hip tuberculosis. The remaining 45 patients in the study group included thirty-eight men and seven women with an average age of 50.9 ± 14.8 years.

Systems of tuberculous acetabular defect classification

Type 1: Lesions are located in the superior dome, anterior wall, or posterior wall. The lesions lyse the cartilage and cancellous bone, but they do not cause perforation; the acetabular rim, medial wall, and both columns remain intact. Type 1 includes three subtypes.

Type 1A: Localized lesions in the superior dome, anterior wall, or posterior wall. The magnitude of the defect is less than or equal to 10 mm (Figure 1, Figure 2).

Type 1B: Localized lesions in the superior dome, anterior wall, or posterior wall. The magnitude of the defect is over 10 mm (Figure 1, Figure 3).

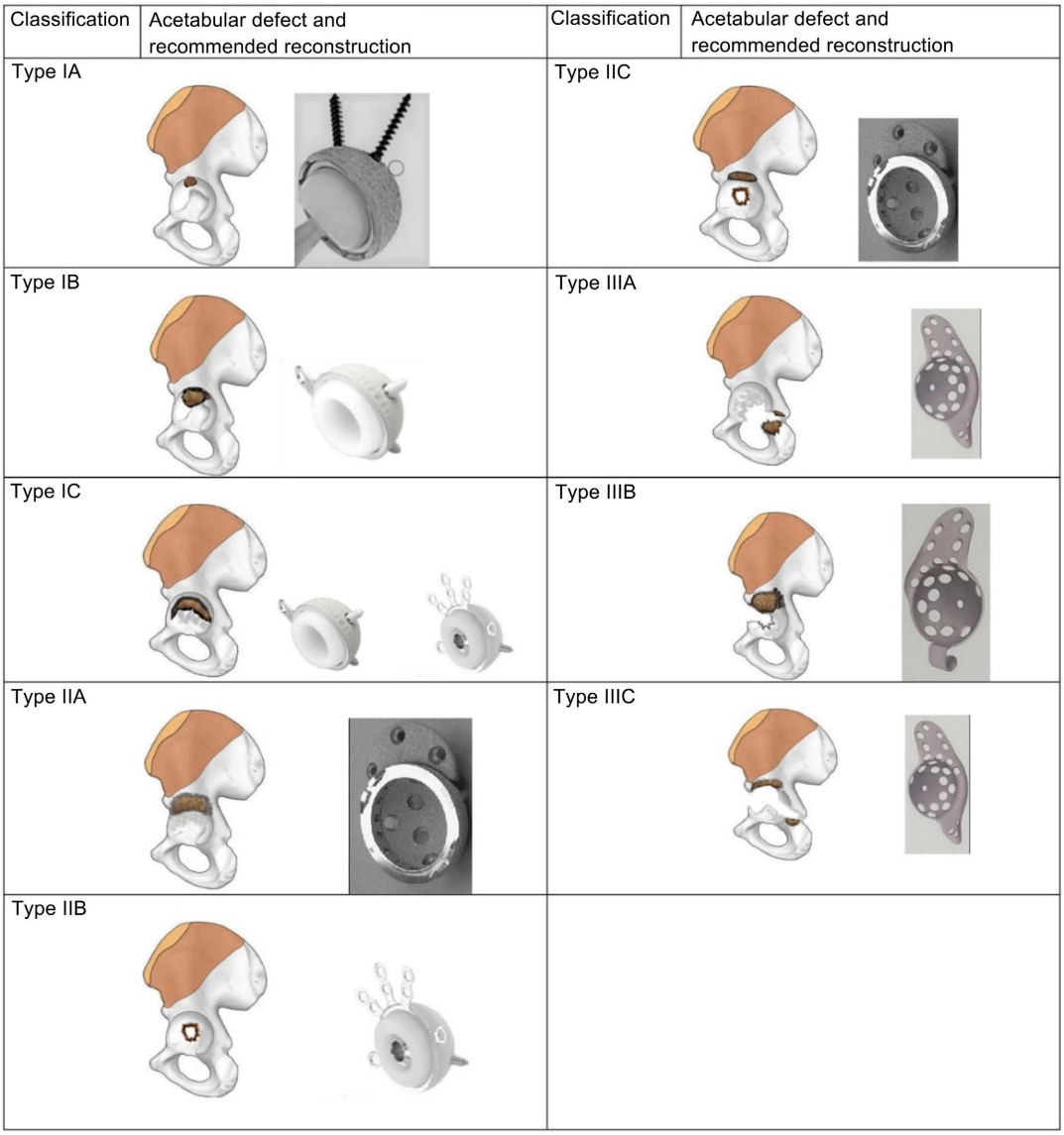

Figure 1. Illustration of a tuberculous acetabular defect and recommended reconstruction.

Figure 2. Male, 64 years old, right acetabular defect type IA.

Figure 3. Female, 64 years old, left acetabular defect type IB.

Type 1C: Extensive lesion inside the acetabulum causing cartilage and cancellous bone damage (wandering acetabulum) (Figure 1, Figure 3).

Type 2: Extensive cancellous bone damage associated with rim fracture at a weight-bearing position or (and) with a disrupted medial wall. Both columns remain intact. Type 2 includes three subtypes.

Type 2A: Cancellous bone defect of the superior dome over 10 mm associated with acetabular rim fracture in a weight-bearing position (Figure 1, Figure 5).

Type 2B: Tuberculous lesion causes medial wall disruption (Figure 1, Figure 6).

Type 2C: Tuberculous lesion causes acetabular rim fractures and medial wall disruption.

Type 3: Acetabular lesion disrupts the medial wall and destroys the column. Type 3 includes three subtypes.

Type 3A: Tuberculous lesion disrupts the medial wall and destroys the posterior column (Figure 1, Figure 7).

Type 3B: Tuberculous lesion disrupts the medial wall and destroys the anterior column (Figure 1, Figure 8).

Type 3C: Tuberculous lesion disrupts the medial wall and destroys both columns, with pelvic discontinuity (Figure 1, Figure 9).

Figure 4. Male, 61 years old, left acetabular defect type IC.

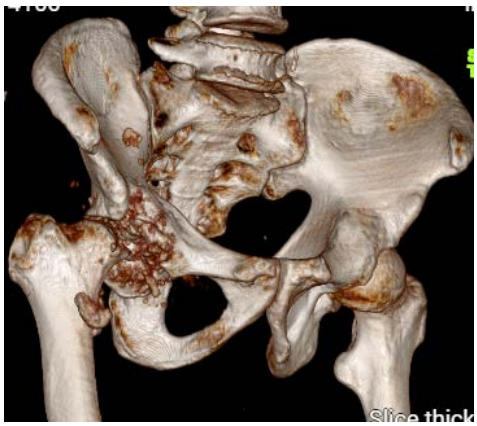

Figure 5. Male, 59 years old, right acetabular defect type IIA.

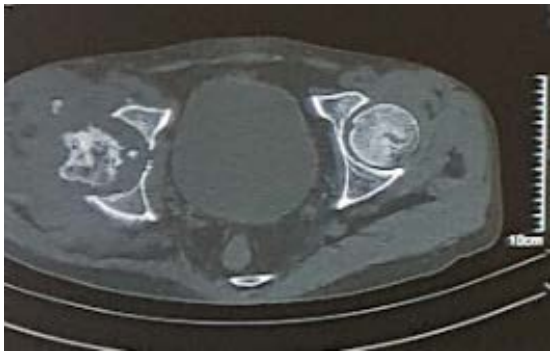

Figure 6. Female, 40 years old, right acetabular defect type IIB.

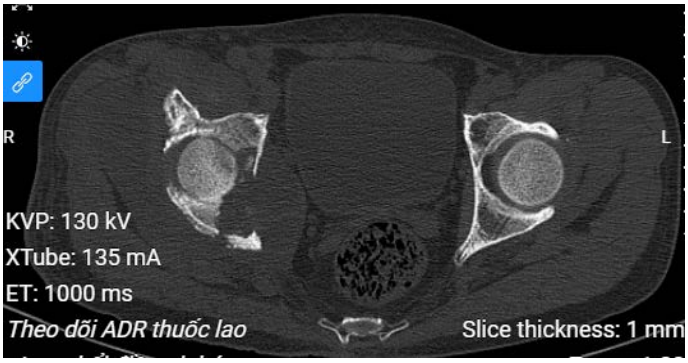

Figure 7. Male, 59 years old, right acetabular defect type IIIA.

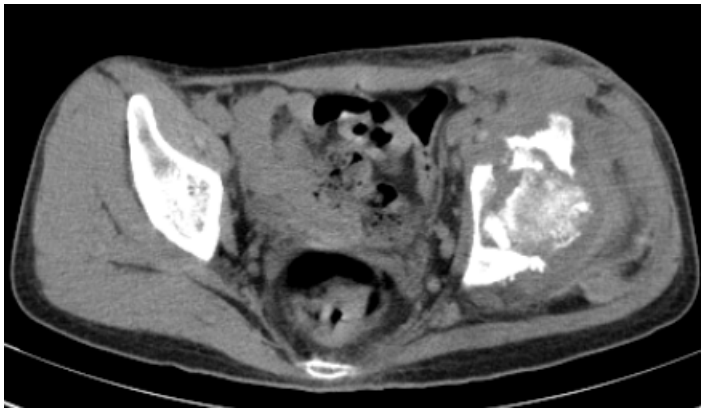

Figure 8. Male, 39 years old, left acetabular defect type IIIB (anterosuperior rim fracture, medial wall disruption, anterior column destruction).

Figure 9. Male, 62 years old, left acetabular defect type IIIC.

Recommended reconstruction of tuberculous acetabular defect (Table 1, Figure 1)

Outcome of hip arthroplasty according to the classification (Table 2)

4. Discussion

One feature of tubercle bacilli, which is different from other pyogenic bacteria, is its ability to destroy bone, creating gross bony lesions [7] [14]. In tuberculosis of the hip, any proximal femur damage can be resolved by conventional joint replacement procedures. However, acetabular destruction is more problematic, requiring a preoperative diagnosis and an appropriate intraoperative acetabular reconstruction approach.

In reviewing the literature, we did not find any separate reports about tuberculous acetabular defect characteristics. However, we could perceive some specific information about bone and joint tuberculosis. Phermister proposed a radiologic triad for joint tuberculous diagnosis [15] [16].

- Narrowed joint space
- Periarticular osteoporosis
- Localized osseous erosion.

In hip tuberculosis, osseous erosion usually occurs at the acetabulum and proximal femur. A typical tuberculous erosion has a wedge shape [14].

Table 1. Acetabular defect classification and recommended reconstruction.

Classification	Recommended reconstruction
Type 1A	Hemispherical cup
Type 1B	Hydroxyapatite filling in the defect Hemispherical tripod cup
Type 1C	Hemispherical tripod cup or hemispherical cup with screw flanges
Type 2A	Consider high hip center technique or jumbo cup or trabecular metal augment
Type 2B	Hemispherical cup with screw flanges
Type 2C	Trabecular metal augment
Type 3A	Reinforcement cage
Type 3B	Reinforcement cage
Type 3C	Reinforcement cage or consider doing a Girdlestone procedure

Table 2. Outcome of hip arthroplasty according to the classification.

Classification	Number of patients	Reconstruction	Average time follow up (months)	Dislocation	Outcome
1A	4	Hemispherical cup	33.3 ± 14.7	0	4/4 excellent
1B	3	Tripod cup	24.3 ± 9.1	0	3/3 excellent
1C	12	8 Tripod cup 4 cup with screw flanges	37.1 ± 13.7	0	8/8 excellent 3/4 excellent 1/4 good
2A	15	Jumbo cup	20 ± 4.1	0	14/15 excellent 1/15 good
2B	5	Cup with screw flanges	38.3 ± 8.5	0	5/5 excellent
2C	2	trabecular metal augment	27 ± 2.8	0	2/2 excellent
3A	2	Reinforcement cage	25	0	1/2 excellent 1/2 good
3B	1	Reinforcement cage	24.6 ± 4.6	0	5/5 excellent
3C	1	Girdlestone procedure	46	N/A	1/1 poor

N/A: not applicable.

Shanmughasundaram in 1983 revealed his radiologic hip tuberculosis classification [17]. It was not only a sorting mechanism but also a critical report about the tuberculous acetabular lesion because his classification revealed the defect in each class, such as "traveling acetabulum", "dislocating", "protrusio acetabuli", or "mortar and pestle".

When observing radiographs in some studies about prosthetic joint tuberculosis infection, we found that hip prosthesis failure could occur after an acetabu-

lar defect. [18] [19] [20] [21] In several reports about total hip replacement for tuberculosis of the hip, the authors showed some hip radiographs with acetabular defects [4] [22] [23] [24] [25]. Unfortunately, they did not analyze the defects in detail. Thus, the acetabular lesions of hip tuberculosis are a burdensome area to explore.

Identifying lesions and planning acetabular reconstruction requires a classification system of acetabular defects for the tuberculous hip. There are some widely used acetabular defect classifications, including Paprosky's [10], D'Antonio's [9], and Granem's classifications [11]. However, these classification systems are designed for only hip replacement with noninfectious lesions. In tuberculosis of the hip, there are different characteristics of the defects, including the site, magnitude, environmental properties and level of destruction. Applying Paprosky's classification [10], we need data on the destruction of the medial wall, anterior column, posterior column, hip center migration, and bone loss proportion. In hip tuberculosis, there is often destruction of the femoral head. Sometimes, the femoral head disappears, so measuring the hip center's migration is challenging. In addition, the analysis of bone loss is quite complicated and impractical used in tuberculous acetabular defect. We also have difficulty applying other classifications systems for hip tuberculosis. Experts have discrepancies when rating the lesion and choosing how to reconstruct it. Therefore, a classification system of tuberculous acetabular defects is necessary. It provides a good reference in the challenging field of hip replacement.

We found some characteristic features of tuberculous acetabulum lesions in the study group. Tuberculous defects predominantly occurred at the direct contact locations with the femoral head, such as the superior dome, anterosuperior rim, medial wall, and anterior column. In some exceptional cases, the tuberculosis lesions were primarily present in the posterior column, causing destruction. In cases with both anterior and posterior columns damaged, severe osteoporosis often co-occurred. The damage could be localized or extensive depending on the tuberculosis stage and the infection response of each patient. Localized defects are benign and easier to manage than extensive lesions. All acetabulum defects should be considered and restored in hip replacement; if not, the artificial cup may be dislocated or protrude.

Regarding our classification, there is no image noise caused by a remaining artificial joint, as in revision hip arthroplasty, so the lesions are observed clearly and evaluated strictly based on plain X-rays and computed tomography scan images. We had no difficulty classifying any of the cases. In each case, three experts agreed on the preoperative classification. There was no discrepancy between the preoperative and intraoperative classification. We did not apply the proportion of bone loss to our classification because quantifying the percentage of bone loss is complicated and unnecessary in a tuberculous acetabulum defect.

In type 1 (**Table 1**, **Figure 1**), the main structure of the acetabulum is intact. We could perform hip replacement with a standard hemispherical cup. For type 1B (**Table 1**, **Figure 1**, **Figure 3**), it is advocated to curette the lesion and fill it

with hydroxyapatite to avoid the damage from spreading, causing the cup to loosen [26]. For type 1C (**Table 1**, **Figure 1**, **Figure 4**), care should be taken when reaming the socket to remove the cartilage and dead bone while avoiding acetabular perforation. We favored using a tripod hemispherical cup or hemispherical cup with screw flanges to fix the cup firmly [27]. In type 2 (**Table 1**, **Figure 1**), the lesion extends to the rim and (or) medial wall of the acetabulum. For type 2A (**Table 1**, **Figure 1**, **Figure 5**), it is necessary to repaire fracture of the acetabulum rim at the weight-bearing position. Otherwise, it will cause instability of the artificial cup and loosening later. There are many ways to overcome, including using a jumbo cup, high hip center technique, bone grafting, or trabecular metal augment [28] [29] [30]. As mentioned above, it is advisable to restrict bone grafting in the area of tuberculosis infection, so we backed using a trabecular metal component to repair the acetabular structure in the best way. In type 2B (**Table 1**, **Figure 1**, **Figure 6**), the damage is mainly in the medial wall causing perforation. However, the two columns still have their supporting function so that the hip joint can be replaced without the need for a cup-cage system. It is endorsed to use the hemispherical cup with screw flanges to firmly fix the new socket, preventing the acetabulum protrusion. Type 2C (**Table 1**, **Figure 1**) is a complex lesion that damages the acetabulum rim and the medial wall. It is recommended to use a trabecular metal augment. Due to damage to the medial wall and column in type 3 (**Table 1**, **Figure 1**, **Figures 7-9**), it is imperative to use a cup-cage system to prevent protrusion [31]. Like a reinforcement cage. Otherwise, surgery will fail with artificial joint dislocation.

We evaluated the outcome of hip replacement after at least one year (**Table 2**). Out of 45 patients who had a hip replacement, 41/45 patients had excellent results, a Harris hip score over 90; and 3/45 patients had good outcomes, a Harris hip score of 81 - 90. The patients had good results due to nerve and muscle damage caused by tuberculosis not related to the acetabular defects.

For 1 case of tuberculous acetabular defect type IIIC (**Table 2**) and pelvis discontinuity, because the patient was complicated by severe osteoporosis and chronic obstructive respiratory disease, we considered not replacing the joint but instead performing as limited surgery as possible for the patient. Therefore, we performed the Girdlestone procedure on the patient.

With the above results, it can be seen that our classification system can be easily applied to classify tuberculous acetabular defects, and the outcome of surgical replacement based on our system is also excellent; the artificial hip is stable, and there is neither dislocation nor protrusion. Thus, this classification could be widely applied to help surgeons perform an elaborate field of hip tuberculosis replacement to restore the acetabular defect.

5. Conclusion

This is a simple, practical classification system of acetabular defects in hip tuberculosis. The outcome of hip reconstruction using this classification was ex-

cellent without any cases of dislocation or protrusion.

Limitations

We designed the above classification based on surgically treated patients. Due to the small number of patients (n = 45), the classification system may not be complete and should be supplemented over time.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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Abbreviations

AP: anteroposterior

CT: computed tomography