

# Modified Girdlestone arthroplasty and hip arthrodesis using the Ilizarov external fixator as a salvage method in the management of severely infected total hip replacement

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## ABSTRACT

**Background:** Resection arthroplasty or hip arthrodesis after total hip replacement (THR) can be used to salvage the limb in case with deep infection and severe bone loss. The Ilizarov fixator provides stability, axial correction, weight-bearing and good fusion rates.

**Materials and Methods:** We retrospectively assessed the outcomes of 37 patients with severe periprosthetic infection after THR treated between 1999 and 2011. The treatment included implant removal, debridement and a modified Girdlestone arthroplasty (29 cases) or hip arthrodesis (seven cases) using the Ilizarov fixator. The Ilizarov fixation continued from 45 to 50 days in the modified arthroplasty group and 90 days in the arthrodesis group. One case was treated using the conventional resection arthroplasty bilaterally.

**Results:** Eighteen months after treatment, infection control was seen in 97.3% cases. Six hips were fused as one patient died in this group. Limb length discrepancy (LLD) averaged 5.5 cm. The Harris hip score ranged from 35 to 92 points. Hip joint motion ranged from 10° to 30° in the modified arthroplasty group. All subjects could walk independently or using support aids. No subluxation or LLD progression was observed.

**Conclusion:** The modified Girdlestone arthroplasty and hip arthrodesis using the Ilizarov apparatus results in sufficient ability for ambulation and good infection control in cases of failed THR associated with severe infection.

**Key words:** Arthrodesis, Girdlestone arthroplasty, Ilizarov, infection, total hip replacement

**MeSH terms:** Arthroplasty, arthrodesis, replacement, hip, infection

## INTRODUCTION

Infection in total hip replacement (THR) continues to be a substantial economic and physical burden for patients and the healthcare system. The reported incidence is from 0.5% to 2% following primary THR<sup>1-4</sup> Having increased in the past decade, the average rate is now at about 1.6%.<sup>5</sup> However, the absolute number of infected cases as well as the total number of revision THR procedures tend to be increasing. Chronic

purulent infection after THR is associated with a substantial mortality and more failures are observed in elderly patients.<sup>6-11</sup>

Total hip replacement with severe bone destruction and deep infection in periarticular soft tissues requires radical bone removal followed by resection arthroplasty or joint fusion.<sup>12-15</sup> Resection arthroplasty was first described by G. R. Girdlestone<sup>16</sup> and is still used.<sup>14</sup> The procedure can be used as a rescue technique for infected THR in the situations in which reimplantation is impossible or doubtful.<sup>12-14,17-24</sup> It controls infection in most cases, but leaves the patients with a poor ability to ambulate due to the instability at the pseudoarthrosis. Hip arthrodesis is not regarded as functional, but remains one of the ultimate methods to rescue a limb in difficult situations and studies show good hip fusion rates using external fixation.<sup>15,25,26</sup> It is known that the Ilizarov apparatus provides bone stability in the settling of osteomyelitis and there are reports that describe the use of external fixators for solid fusions of large joints with recurrent osteomyelitis.<sup>27</sup> Recent reports also show that these methods have remained therapeutic alternatives when patient perceived effect on the quality of life is concerned by patients.<sup>28</sup> Both solutions were considered as salvage procedures in the management of severe infection around the implant. This may be

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temporary measure with the perspective to convert them to THR over time.<sup>15,25,26,29-31</sup>

We developed a modified Girdlestone arthroplasty and hip arthrodesis using the Ilizarov apparatus for cases with severe infection following THR and studied its outcomes.

## MATERIALS AND METHODS

37 consecutive patients treated for severe THR infection between 1999 and 2011 at our specialized centre which uses the Ilizarov method and is a referral centre for cases from the entire country were retrospectively assessed.

The study was approved by the Institutional Scientific and Ethic Committees and was conducted in accordance with the ethical standards laid down in the declaration of Helsinki. An informed consent was obtained from all patients.

Patients' clinical details and infective microbes are presented in Tables 1 and 2 respectively. All patients had an extensive bone destruction both in the acetabulum and the femur [Table 1] as well as deep periarticular soft tissue infection [Figure 1a]. There

were three cases of 3A or 3B acetabulum defects developed due to the migration of the implant component into the pelvic cavity. The mean number of previous operations on the hip were 2.89/patient including primary and revision THRs.

Two treatment protocols were used: A modified Girdlestone arthroplasty and hip arthrodesis, both with using the Ilizarov apparatus. Twenty-nine patients underwent the modified Girdlestone procedure and hip arthrodesis was attempted in seven. Definite indication for Ilizarov hip arthrodesis was a compromised contralateral joint affected by advanced idiopathic or posttraumatic osteoarthritis that required THR or had been previously treated and partially loaded [Figure 2a]. Conventional resection arthroplasty was used in one case of this series that had bilateral infected THRs and therefore the Ilizarov circular hip fixation was not applicable on both hips simultaneously due to discomfort and inability to provide weight bearing even with the apparatus on one side.

## Intervention

The intervention in both groups ran in the following sequence. The hip was approached using the Hardinge



**Figure 1:** Radiograph of right hip joint anteroposterior view of a 43 year old woman with (a) total hip replacement infected presented in December 2006 showing bone deficit in the femur and acetabulum around an unstable implant placed in 1994 [Table 3, case 4, modified arthroplasty group] (b). Femur supported into the upper edge of the acetabulum and fixation with the Ilizarov apparatus (c). Radiographs of the pseudoarthrosis formed and femur adduction and abduction after Ilizarov apparatus removal in January 2007 (d and e). Distal femur lengthening in 2008 (f). Hip abduction and adduction in July 2013

**Table 1: Clinical details of patients**

Parameter	Number of cases
Mean age (years): 55.6 (25-77)	
Sex	
Males	22
Females	15
Physical status (ASA)	
Class I	5
Class II	23
Class III	9
Arthrosis type	
Posttraumatic	22
Idiopathic	13
Displastic	2
Primary THR	30
Revision THR	7
Number of previous hip operations	
1-2	2
3-5	23
>5	12
Prosthesis type	
Cemented	10
Hybrid	5
Cementless	18
Muller or Burch-Schneider ring	4
Radiographic findings	
Stable	8
Cup loosening	14
Stem loosening	8
Loosening of both components	7
Infection phase according to Tsukayama	
Acute postoperative	11
Late chronic	8
Acute hematogenous	11
Positive intraoperative cultures	7
Local status	
Wounds	2
Sinuses	32
Swelling, hyperemia of postoperative scar	3
Femur defects (according to Mallory)	
Type 1	10
Type 2	11
Type 3	14
Type 4	2
Acetabulum defects (according to Paprosky)	
Type 1	14
Type 2	4
Type 2A	3
Type 2B	4
Type 2C	7
Type 3	2
Type 3A	1
Type 3B	2

ASA=American Society of Anesthesiologists, THR=Total hip replacement

surgical approach.<sup>32</sup> Sinuses were marked with a brilliant green dye in order to visualize their purulent ramifications. Next, the THR scars and the sinuses were dissected,

implants were removed and a careful debridement was performed. Pulsed lavage of the wound with 0.2% Lavasept solution (B. Braun Medical AG, Switzerland) followed. Gauze pieces soaked in the solution were placed into the femoral medullary canal and in the acetabulum after the lavage. The wound was closed temporarily.

The mounting of the Ilizarov apparatus started with the insertion of five half-pins into the iliac wing that were attached to an Ilizarov hip arch [Figure 3]. Next, two wires were drilled into the middle third of the femur and three wires into its lower third. The wires were fastened on the middle and distal apparatus rings. Temporary sutures and gauze pieces were taken off to open the joint. The proximal end of the femur was refreshed and inserted into the acetabulum, or to its upper edge in case of an interior acetabular defect. The femur was positioned functionally (10°–20° of abduction from the middle line in both groups, flexion from 10° to 20° in the arthrodesis group). The external arch and the rings were connected with threaded rods and hinges. The maximum contacting surface between the proximal femur end and the acetabular bottom was achieved by adjusting the rods and hinges [Figure 1b]. Grafting was not used for fusion.

Draining was achieved with two active systems. One was placed at the hip level, and the other ran through an additional hole drilled laterally in the distal area of the removed stem [Figure 3]. Finally, the wound was closed in layers.

### Postoperative care

All patients were administered intravenously antibiotics for 2 weeks after the operation. The type of antibiotic depended on the infectious microbe and individual sensitivity. Patients were encouraged to stand on the day two or three after the intervention. On the 1<sup>st</sup> day, they learned to bear weight on the operated limb but then started walking using crutches. Leg length discrepancy (LLD) was compensated with shoe raise. Drains were removed on day four or five.

The external fixation protocols in the postoperative period were different in our groups. In the modified Girdlestone arthroplasty group, the proximal femur was first kept fixed rigidly in the acetabulum for 30 or 35 days. The patients bore full weight on the limb during that time. Later on, the hinges were released for doing active or passive joint exercises and partial weight bearing was allowed during 10–15 days until frame removal. The Ilizarov frame was kept for 40 to 50 days. After frame removal patient was mobilized on hip braces immobilization and crutches was indicated for 2 months.

Stable and rigid fixation with the Ilizarov apparatus for hip fusion continued from 85 to 90 days in the arthrodesis

Table 2: Summary of infection microbes

Patient	Before operation	Postoperative reinfection
Modified Girdlestone subgroup		
1	<i>S. aureus</i>	<i>S. aureus</i>
2	<i>S. Cohnii</i> MRSC <i>S. epidermidis</i>	-
3	<i>S. aureus</i> and <i>Enterobacter cloacae</i>	<i>S. aureus</i> MRSA
4	<i>S. aureus</i>	<i>S. aureus</i> and <i>S. epidermidis</i>
5	<i>S. epidermidis</i> MRSE	
6	<i>S. aureus</i>	<i>S. aureus</i>
7	<i>S. aureus</i> and <i>Micrococcus</i> sp.	-
8	<i>S. aureus</i>	-
9	<i>S. aureus</i>	<i>S. saprophyticus</i> and <i>S. epidermidis</i>
10	<i>S. aureus</i>	<i>S. aureus</i> and <i>P. aeruginosa</i>
11	<i>S. aureus</i> , <i>S. aureus</i> MRSA and <i>S. epidermidis</i> MRSE	<i>S. aureus</i> MRSA
12	<i>S. aureus</i> and <i>Enterobacter cloacae</i>	<i>S. aureus</i>
13	<i>S. aureus</i>	-
14	<i>S. aureus</i>	-
15	<i>S. aureus</i>	-
16	<i>S. aureus</i>	-
17	<i>S. aureus</i>	<i>E. coli</i> , <i>K. pneumoniae</i> and <i>P. aeruginosa</i>
18	<i>Serratia marcescens</i> , <i>S. aureus</i> and <i>Streptococcus</i> group B	<i>P. aeruginosa</i> , <i>S. aureus</i> , <i>Enterococcus</i> sp. and <i>Acinetobacter</i> sp.
19	<i>Enterobacter</i> sp. and <i>S. epidermidis</i> MRSE	<i>Enterococcus</i> sp. and <i>S. epidermidis</i>
20	<i>S. aureus</i>	<i>S. aureus</i>
21	<i>Enterobacter</i> sp.	-
22	<i>S. aureus</i>	-
23	<i>S. aureus</i> MRSA	<i>S. aureus</i> MRSA and <i>A. baumannii</i>
24	<i>Enterobacter</i> sp.	<i>S. aureus</i> MRSA
25	<i>Enterobacter</i> sp., <i>S. epidermidis</i> MRSE and <i>Serratia marcescens</i>	-
26	<i>S. aureus</i>	-
27	<i>S. aureus</i>	-
28	<i>S. aureus</i>	<i>S. aureus</i>
29	<i>S. aureus</i>	-
30	<i>S. epidermidis</i>	<i>S. epidermidis</i>
Arthrodesis subgroup		
31	<i>S. aureus</i>	-
32	<i>S. aureus</i> , <i>S. saprophyticus</i> and <i>P. aeruginosa</i>	<i>E. faecalis</i> and <i>S. epidermidis</i>
33	<i>S. aureus</i>	-
34	<i>S. aureus</i>	-
35	<i>S. aureus</i>	-
36	<i>S. aureus</i>	-
37	<i>E. faecalis</i>	<i>Enterobacter</i> sp. and <i>P. aeruginosa</i>

MRSA=Methicillin-resistant *Staphylococcus aureus*, MRSE=Methicillin-resistant *Staphylococcus epidermidis*

group. The arthrodesis patients were recommended to full weight bearing on the limb with Ilizarov apparatus and after the removal of the Ilizarov apparatus as well.

Radiography, laboratory tests (erythrocyte sedimentation rate, C-reactive protein, leukocyte count), clinical examination for absence of sinuses, Harris hip score (HHS)<sup>33</sup> system and interviewing for patient's satisfaction were used to study during immediate and long term followup. We assessed the reinfection rate and infection control, pain relief, LLD, walking ability, use of orthopedic means for walking, HHS, patients' satisfaction and major complications.

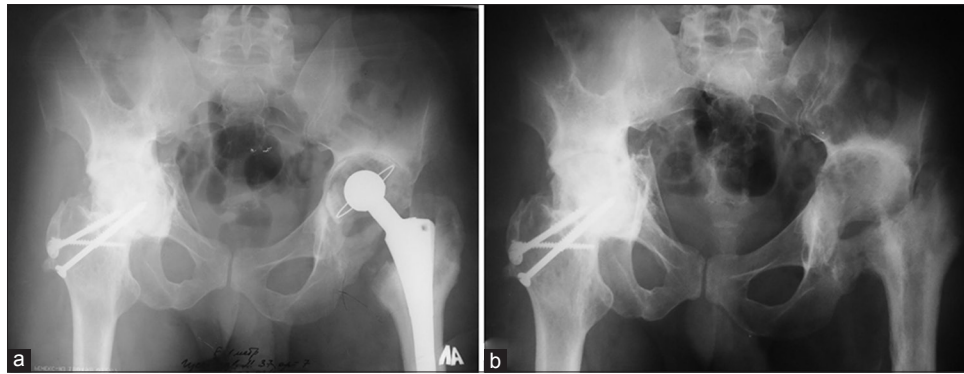
## RESULTS

All patients were available for followup after 18 months [Table 3]. Nine patients appeared for followup at a mean period of 74.5 months (range 18–132 months).

### Radiographic control

At followups, neither proximal femur dislocation from the acetabulum nor bone sequestration was observed in the modified Girdlestone group. Radiographs were taken in this group under loading, in abduction and adduction, extension and flexion of the femur to assess the joint motion which





**Figure 2:** (a) Radiograph of a 37-year-old male [Table 3, case 2, arthrodesis subgroup] showing an unstable implant and acetabular bone deficit in the left hip (b) Posttraumatic osteoarthritis and screw fixation affect the functions of the right hip which was partially loaded. The left hip was fused for better supportability

was in the range of 10° to 30° [Figure 1c and f]. Six hips fused [Figure 2b].

### Infection control

Reinfection developed within 1-month after the operation in 48.5% of patients ( $n = 16$ , in the arthroplasty group and  $n = 2$ , in the arthrodesis group) [Table 2]. Reinfection was caused by persistent infection caused of *Staphylococcus aureus* and other mixed types of infection [Table 2]. Debridement and a 2 weeks administration of antibiotics were repeated. The repeated debridement index per patient was 0.49. The overall infection control was 97.3% upon completion of treatment. One patient aged 67 years with associated hypertension and encephalopathy died due to polyorgan failure and sepsis.

### Pain

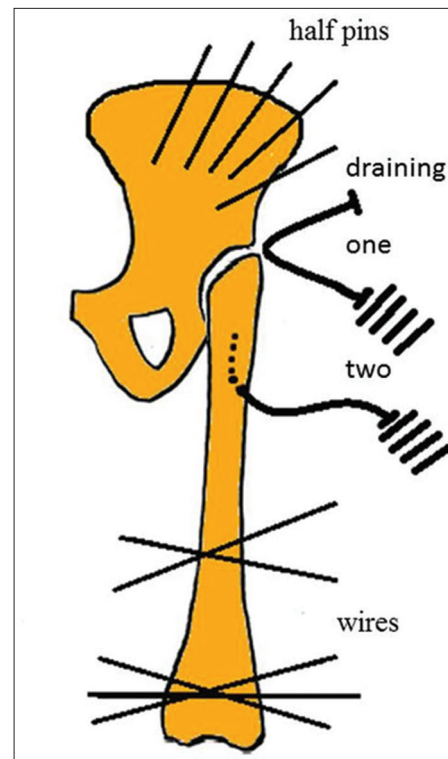
According to HHS survey, pain was absent or mild in 66.7% in the modified arthroplasty group. Ten subjects from this group (33.3%) felt temporary moderate pain only during walking. Back pain was mild in the arthrodesis group.

### Leg length discrepancy

The mean residual LLD was of 5.2 cm in the modified arthroplasty group and 5.8 cm in the arthrodesis group. The large variance was due to the initial LLD that measured from 2 cm to 10 cm in eight cases, out of which seven had more than 7 cm of final shortening and in one case due to several resections. LLD did not increase at further followups. We reduced limb shortening from 10 cm to 3 cm in one female by a lengthening procedure in the lower third of the femur [Figure 1d and e]. There was no LLD in one case of bilateral conventional Girdlestone procedure without application of the Ilizarov apparatus.

### Functional ability

HHS at 18 months followup is shown in Table 3. Four patients in the modified arthroplasty group did not use



**Figure 3:** Schematic diagram showing the location of half-pins and wires for fixation and placement of draining systems

any means of support in daily activities or used them only for long distances. All the rest could walk using crutches or a cane. None used a wheel chair except the patient with bilateral conventional arthroplasty. The range of joint motion measured from 10° to 30° in this group.

### Patients' satisfaction

Patients were asked whether they were satisfied or unsatisfied with their treatment outcomes [Table 3]. Their subjective satisfaction was 76.7% in the modified Girdlestone group and 50% in the survived cases of arthrodesis. In the whole series, 72.2% of the survived patients were satisfied with the final outcomes.

**Table 3: Patient's outcomes at 1.5 years followup**

Number	Year of surgery	Age (in years)	Pain	Walking aids	LLD* cm	Satisfaction as expressed by patients	HHS
Modified Girdlestone subgroup							
1	2004	65	Moderate temporal	Cane	5	Satisfied	58
2	2005	35	Absent	None	6	Satisfied	78
3	2006	54	Moderate temporal	1 crutch	5	Satisfied	56
4	2006	43	Absent	None	3	Satisfied	92
5	2007	60	Mild	1 crutch	10	Unsatisfied	69
6	2008	77	Moderate temporal	1 crutch	6	Satisfied	56
7	2008	58	Mild	1 crutch	4	Satisfied	69
8	2008	52	Mild	1 crutch	5	Satisfied	69
9	2008	72	Mild	Cane	5	Satisfied	75
10	2008	64	Moderate temporal	Wheel-chair and other person's support	0	Satisfied	39
11	2008	58	Moderate temporal	1 crutch	7	Unsatisfied	49
12	2009	69	Mild	Cane	5	Satisfied	71
13	2009	39	Mild	1 crutch	13	Unsatisfied	62
14	2009	69	Absent	Cane, temporarily	3	Satisfied	90
15	2009	56	Mild	1 crutch	4	Satisfied	69
16	2010	57	Absent	Cane	6	Satisfied	77
17	2010	42	Absent	Cane, temporarily	3	Satisfied	87
18	2010	25	Mild	Cane	5	Satisfied	71
19	2011	54	Mild	Cane	7	Satisfied	71
20	2011	59	Mild	2 crutches	10	Satisfied	61
21	2011	52	Absent	Cane	7	Unsatisfied	80
22	2011	56	Moderate temporal	1 crutch	4	Satisfied	60
23	2011	66	Moderate temporal	1 crutch	3	Satisfied	64
24	2011	62	Moderate constant	2 crutches	3	Unsatisfied	35
25	2011	63	Moderate temporal	2 crutches	5	Unsatisfied	35
26	2011	49	Absent	Cane	3	Satisfied	80
27	2011	35	Absent	1 crutch	4	Satisfied	74
28	2011	56	Moderate temporal	1 crutch	7	Unsatisfied	74
29	2011	57	Absent	Cane	3	Satisfied	84
30	2011	72	Mild	1 crutch	4	Satisfied	73
Arthrodesis subgroup							
1	1999	65	Mild	Cane	12	Unsatisfied	65
2	2002	37	Absent	Cane	4	Satisfied	70
3	2003	57	Mild	Cane	6	Unsatisfied	70
4	2003	41	Mild	Cane	6	Unsatisfied	65
5	2005	57	Absent	Cane	3	Satisfied	70
6	2009	56	Mild	Cane	4	Satisfied	71
7	2009	67	Died	-	-	-	-

\*LLD=Leg length discrepancy, HHS=Harris hip score

### Major complications

One patient had an intraoperative periprosthetic fracture of the femur that was successfully reduced and fixed with the Ilizarov frame during surgery. Pin tract infection was noted but mostly in the arthrodesis group due to a longer total fixation period. It was treated by antiseptic dressings or reinsertion of wires. As mentioned previously, one woman died of uncontrolled infection.

### DISCUSSION

There are few but favorable literature reports on the use of the Ilizarov fixation in cases of compromised THR.<sup>31,34</sup> Previous

studies of hip arthrodesis with the use of external fixation have shown good fusion rates and its applicability for young patients with the expectation to convert it to THR later.<sup>15,25</sup> The treatment aim of the modified Girdlestone procedure combined with the Ilizarov osteosynthesis was to achieve functional pseudoarthrosis. Some authors modified the Girdlestone arthroplasty for patients who had minimal defects in the hip bones to make it more functional. Our modification serves to treat the most severe infected hip defects after THR that require radical bone resection [Table 1].<sup>35</sup>

Therefore, we should point out the main differences of our modified technique. First, we bring the proximal end of the femur

into the acetabulum and rigidly immobilize the hip joint with the Ilizarov apparatus until a good fibrous binding has been formed, strong enough to avoid dislocation. Unlike our procedure, the outcome of the conventional resection arthroplasty is that proximal femoral ends do not rest in the true acetabulum but in the scar formed. Therefore, the patients cannot bear full weight on the leg after treatment, and LLD can progress due to the migration of the femoral end or fibrous scar rupture that both provoke pain and infection recurrence.<sup>23</sup> Second, the use of the Ilizarov method enables early mobilization of patients. They start walking on the first postoperative day with full weight bearing on the affected extremity. Weight bearing and joint immobilization during 6–7 weeks provide better conditions for fibrous callus formation at the docking site which is similar to neoarthrosis, strengthen it and reduce the possibility of infection recurrence. On the contrary, hip instability due to subluxation and muscle loss are common after the resection arthroplasty when it is used alone.<sup>17,23</sup>

Conventional resection arthroplasty aids to control infection, relieves pain but leaves the patients with a very small range of motion instability and the need of orthopedic aids or wheel-chairs. Unanimously, the functional results of standard resection arthroplasty are assessed as poor in the available literature.<sup>12-14,17-24</sup> As reported, almost half of geriatric patients were unable to walk; only one third could ambulate using supporting devices.<sup>14,17,22</sup> All our elderly patients were able to walk after completion of treatment with the Ilizarov apparatus. Younger patients used additional aids of ambulation only for security at longer distances.

As it was shown, hip arthrodesis yields excellent fusion rates with the use of external fixation or internal fixation means.<sup>15,25</sup> However, it was a rarely used procedure during the study period and was applied in very selective cases with either an affected contralateral hip or when preferred by the patient`.

Correct Ilizarov frame placement is also essential vis-a-vis biomechanical issues as it foresees bone length and axis control.<sup>34</sup> Lengthening is possible at the expense of the osteotomy which can be done at distal femur by distraction. However, only one patient was eager to proceed with lengthening in the second stage, 2 years after the initial

treatment. Twelve patients (40%) had LLD within 3 cm to 4 cm and a compensatory external shoe sole was enough for satisfactory walking.

A limitation of our study was absent control groups as we do not perform conventional resection arthroplasties. Therefore, we can compare our outcomes after the modified Girdlestone arthroplasty only with the available data on resection arthroplasties following infected THR in literature [Table 4]. Our approach could improve some of the unfavourable outcomes of conventional resection arthroplasty. The final infection control was 100% in our patient. High rates of infection control following conventional resection arthroplasty for infected THR is also reported, but high mortality rate is documented by other authors.<sup>22</sup>

Apart from infection eradication, our main goals were patients' independence in daily activities and freedom from pain. Obvious reduction of pain after the Girdlestone operation was reported in the studies, but severe residual pain was also observed.<sup>12,14,17-19,22,24</sup> In our modified arthroplasty group, the ratio of absent to mild and temporary moderate pain was 9:11:8 respectively. There was only one patient who experienced constant moderate pain after 18 months. There were no cases of severe residual pain at all. The HHS range was between 35 and 92. Moreover, the modified Girdlestone technology could provide a sufficient range of motion in the hip for fulfilling daily activities [Figure 1].

Of course, our relatively young patients expected higher functional outcomes. However, the three youngest patients with 3A or 3B acetabulum defects [Table 1] had the HHS score over 70 points and were satisfied with the outcomes. The subjective satisfaction in our modified Girdlestone group was 76.7% that is in agreement with other authors.<sup>14,18,22,24</sup> But it was only 50% in the arthrodesis group.

Both tactical solutions to salvage the limb using the Ilizarov apparatus in cases of severe infection around the implant might have further perspectives to THR conversion. Nevertheless, possible conversion to prosthetic replacement

**Table 4: Summary of resection arthroplasty outcomes according to the available sources as compared to modified Girdlestone arthroplasty**

Authors	Eradication of infection %	Severe pain %	Unable to walk %	Mean LLD* cm	Satisfaction %	HHS
Cordero-Ampuero <sup>14</sup>	80-100	16-33	45% geriatric patients	NA*	13-83	25-64
Hudec <i>et al.</i> <sup>18</sup>	NA*	11	NA*	4.1	78	47-88
Sharma <i>et al.</i> <sup>22</sup>	100	4.3	28.6	NA*	71	NA*
Stoklas and Rozkydal <sup>24</sup>	NA*	16	11	4	74	25-83
Golda <i>et al.</i> <sup>19</sup>	95.5	4.5	0	>3	95.5	Mean 58.6
Esenwein <i>et al.</i> <sup>21</sup>	81.5	7.4	7.4	5.2	53.3	NA*
Modified Girdlestone arthroplasty with the Ilizarov apparatus	97.3-100	0	0	5.2	76.7	35-92

\*NA=Not available, LLD=Leg length discrepancy, HHS=Harris hip score

or the use of other options after the resection arthroplasty is difficult due to large resected areas.<sup>23,36,37</sup> Some available sources showed that the incidence of complications and revisions after conversion was similar to primary THR,<sup>15,30,31</sup> but others reported numerous postoperative complications, high dislocation rate or implant loosening.<sup>26,36</sup>

## CONCLUSION

We conclude that the main outcomes of the use of Ilizarov fixation in our series were the ability of all patients to ambulate and complete eradication of infection. The modified Girdlestone procedure and hip arthrodesis using the Ilizarov apparatus are reasonable solutions to salvage the limb in cases of the difficult peri-prosthetic infection.

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