



## Total hip arthroplasty vs. osteosynthesis in acute complex acetabular fractures in the elderly: Evaluation of surgical management and outcomes

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### ABSTRACT

**Objective:** To retrospectively evaluate the open reduction internal fixation and total hip arthroplasty directions, results and complications associated with internal fixation in managing these fractures.

**Methods:** In 8 years at 4 centers, 61 patients with associated acetabular fractures (Letournel classification) were treated. The patients were divided into two groups. The total hip arthroplasty (THA) group consisted of 30 patients, while the open reduction internal fixation group had 31 patients. The average age of the patients was 74.7 years. The following parameters were compared: the duration of surgery and hospitalization, the international unit of red blood cell concentrate transfusion, the time for the verticalization of the patient, perioperative complications, Harris hip score, and the short form (12) health survey. The clinical and radiographic follow-up was performed at 1 month, 3 months, 6 months and 12 months and annually thereafter. Patients with post-traumatic osteoarthritis formed the third comparison group.  $P \leq 0.05$  was considered statistically significant according to the analytical Student's *t*-test.

**Results:** The  $P < 0.05$  in favor of the THA group was: surgical time, length of stay, number of the international unit of red blood cell concentrate transfusions, verticalization, quality of life and hip function, a reduction of perioperative complications and reinterventions.

**Conclusions:** Our experience shows that the THA treatment for acetabular fractures in the elderly is to be preferred.

## 1. Introduction

The incidence of acetabular fractures in the elderly has recently shown a marked increase in the population, as the consequence of the increased survival rate and daily activities[1]. Furthermore, there is a possibility that the frequency of these injuries will double in less than 15 years[2]. Therefore, in the US, the elderly (17%) represent the subgroup of the total population with the fastest increase of

acetabulum fractures[2]. According to Ferguson *et al.*[3], associated acetabular fractures (Letournel classification) are the most common fractures in the elderly and also the most difficult to treat surgically with a high risk of poor outcomes[3]. In treating these lesions, the decrease of physiological reserve and healing abilities has indeed a negative effect on the possibility of a favorable clinical outcome[4]. Therefore, the acetabular fractures in the elderly may cause disability which could affect not only the life of the patients but also the life of their families. So, the surgical treatment of these fractures is challenging[1-4]. Hip surgeons are still debating between total hip arthroplasty (THA) in osteosynthesis[5] and open reduction internal fixation (ORIF)[6] for the proper management of complex acetabular fractures. However, both surgical procedures are not without risks quoad vitam and quoad valetudinem for the patient[5-7]. The main objective of this study is to retrospectively evaluate the ORIF and THA directions, results and complications associated with internal fixation in managing the acetabular fractures in the elderly (Letournel classification).

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The study protocol was performed according to the Helsinki declaration. Informed written consent was directly obtained from patients.

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## 2. Materials and methods

From January 2008 to May 2016, at the University of Siena, Department of Orthopedics and Traumatology of Hospital Gaetano Rummo, Department of Orthopedics and Traumatology of the Vito Fazzi Hospital, and the Clinic of Traumatology, University Hospital Clinical Center Banja Luka, 61 patients who were older than 65 years and suffered from associated acetabular fractures (Letournel classification) were treated. The average age of the patients was 74.7 years ranging from 65 to 93 years. Among them, there were 40 males and 21 females. The 61 patients were divided into 2 groups according to the surgical procedure used for the operation: 30 patients underwent THA in acute associated with osteosynthesis and 31 patients underwent surgery for ORIF.

All patients were informed in a clear and complete way about the 2 types of surgical treatment with their pros and cons and the corresponding surgical and conservative alternatives. Patients were treated according to the ethical standards of the Helsinki Declaration and were invited to read, understand and sign the informed consent form. The patients' randomization principle was based on their decision of which treatment they decided to choose.

The average follow-up period was 3.3 years, ranged from 3 months to 8 years. The standards taken into account in comparing the two surgical procedures were the following health economic parameters, such as the duration of surgery and hospitalization, the international unit of red blood cell concentrate (IU RBCC) transfusions to quantify blood loss both before and after surgery, the time elapsed from surgery to verticalization of the patient, and the presence of any perioperative complications. The evaluation was also continued with clinical data: the Harris hip score (HHS), the short form (12) health survey (SF-12) and radiographic parameters obtained by tests taken before and after treatment and during follow-up. The follow-up was performed with clinical and radiographic controls at 1 month, 3 months, 6 months and 12 months and annually thereafter. In addition, a third comparison group, made up of patients previously treated with ORIF and returning for observation to undergo hip replacement surgery (POSTORIF), was also evaluated. Patients were given an informed consent prior to being included in the study. All procedures involving human participants were in accordance with the 1964 Helsinki declaration and its later amendments.

### 2.1. THA procedures: surgery notes

Patients were evaluated jointly by the surgical and anesthesiology team. All patients underwent general anesthesia with controlled ventilation with orotracheal intubation. All operations were performed in one session. All patients were in the lateral decubitus and the chosen surgical technique was the posterolateral or posterior (southern) approach, proximally extended with respect of the gluteal artery. In only one female patient, the ilioinguinal approach was used, as she was suffering from pelvic disruption classified as Tile C1 pubic symphysis diastase. The acetabular bone loss was filled with grafts from bone bank and bone chip grafting bone taken from the ipsilateral femoral head removed. The surgical procedure also provided for the posterior stabilization with plates and screws, the use of an anti-protrusion ring in 22 cases and the use of trabecular metal acetabular revision system in 8 cases. The reduction of the anterior segment of the acetabulum was achieved by inserting screws through the anti-protrusion ring or through the acetabular revision. The general concept was to create an A-frame equivalent,

stabilizing both the front and rear columns when necessary. In all 22 cases, inside the anti-protrusion ring a semi-elliptical acetabular cup was cemented, in which a polyethylene insert for the bi-articular mobility was implanted. In the case of revision cups, in their interior, a polyethylene insert was always cemented. Both the cemented acetabular cup and revision cups were implanted into the appropriate place in which they could achieve maximum stability. Also, in both methods, the polyethylene insert was cemented in a range of 15°–35° inclination and of 10°–15° anteversion. The femoral stem implant was decided. In 20 cases a long hydroxyapatite coated stem to achieve metaphyseal fixation was used and in 10 cases the option was a cemented stem due to the scarcity of bone stock at femoral level.

### 2.2. ORIF procedures: technical notes

For all associated fractures treated with the ORIF procedure, the appropriate surgical approach was used according to the site of the fracture (anterior, posterior or combined). The decubitus was supine or prone according to the surgical approach chosen. The entire treatment was performed in a single surgical session. The osteosynthesis was performed with plates and screws. In the 12 cases where it was necessary to further reduce the displacement of the quadrilateral plate. In the first 9 cases "wiper" plates were used, while in the remaining 3 cases, through the normal ilioinguinal approach, over-pectineal and intra-pectineal plates were used.

### 2.3. Statistical analysis

Descriptive statistics were used to summarize the characteristics of the study group and subgroups, including means and standard deviations of all continuous variables. The *t*-test was used to compare continuous outcomes. The *Chi*-square test or Fisher's exact test (in subgroups smaller than 10 patients) were used to compare categorical variables. The statistical significance was defined as  $P < 0.05$ .

## 3. Results

The description of two populations was present in Table 1. A total of 109 comorbidities afflicted the patients in the THA group, while 105 afflicted the patients in the ORIF group (Table 2).

The average length of hospitalization for the THA group was 16.7 days ranging from 10 to 21, while for the ORIF group it was 16.3 days ranging from 10 to 22 days. There was no statistical difference between the two groups ( $P > 0.05$ ) (Table 3). If, instead, we considered the POSTORIF group we had to add up an average of 7.3 days (ranged from 5 to 10) for the operation and there was a statistically significant difference for the THA group (Table 3).

The surgery in both groups was performed between the 5th and 10th day after the trauma while in the ORIF group outcomes it was performed on average of 15.3 months (range: 6–26) after surgery. In only one ORIF case, urgent surgery had to be performed, as the patient, in addition to the acetabular fracture, was suffering from a transcervical fracture which required fixation with cannulated screws.

The average duration of surgical anesthesia in the THA group was 215.6 (range: 180–267) min; in the ORIF group (including the patient position change) was 242.5 min (range: 165–210) ( $P > 0.05$ ) (Table 3). If we take into consideration the sum of the anesthetic surgical time for the ORIF group and the ORIF group outcomes on average of

82.3 min (range: 62–103 min), and there was a  $P < 0.05$  in favor of the THA group (Table 3).

**Table 1**

Description of the two populations.

| Parameters  | THA   | ORIF   |
|---|---|--|
| Number of patients  | 30  | 31   |
| Average age (years)   | 76.7  | 73.2   |
| Range of age (years)  | 65–86   | 65–93  |
| Gender (males: Females)   | 20:10   | 20:11  |
| Male/female ratio   | 2:1   | 1.81:1   |
| Types of fracture associated according Lectorunel classification                | Fracture T: 1 (3.33%)<br>Rear column + rear wall: 8 (26.67%)<br>Transverse + rear wall: 8 (26.67%)<br>Anterior wall + emitrasversa back fracture: 10 (33.33%)<br>Both columns: 3 (10.00%) | Fracture A: 1 (3.22%)<br>Rear column + rear wall: 9 (29.03%)<br>Transverse + rear wall: 10 (32.26%)<br>Anterior wall + emitrasversa back fracture: 9 (29.03%)<br>Both columns: 2 (6.46%) |
| Speed of trauma [n (%)]   | Low energy: 14 (46.67)<br>high energy: 16 (53.33)   | Low energy: 20 (64.52)<br>high energy: 11 (35.48)  |
| Average injury, severity score (range) at the entrance to the Emergency Room    | 22.6 (13–42)  | 22.6 (12–42)   |
| Average Glasgow coma scale (range) at the entrance to the Emergency Room        | 13.4 (10–15)  | 13.3 (9–15)  |
| The American society of anesthesiologists physical status classification system | III in all patients   | III in all patients  |

**Table 2**

Description of comorbidities [n (%)].

| Comorbidity                       | THA (n = 109) | ORIF (n = 105) | Total (n = 214) |
|-----------------------------------|---------------|----------------|-----------------|
| Cardio-vascular diseases          | 29 (13.55)    | 31 (14.49)     | 60 (28.04)      |
| Infarct                           | 3 (1.40)      | 3 (1.40)       | 6 (2.80)        |
| Respiratory diseases              | 15 (7.00)     | 11 (5.15)      | 26 (12.15)      |
| Renal diseases                    | 10 (4.67)     | 7 (3.27)       | 17 (7.94)       |
| Diabetes mellitus                 | 12 (5.61)     | 14 (6.54)      | 26 (12.15)      |
| Rheumatic diseases                | 9 (4.21)      | 7 (3.27)       | 16 (7.48)       |
| Cognitive dysfunction or dementia | 4 (1.87)      | 4 (1.87)       | 8 (3.74)        |
| Smoke                             | 10 (4.67)     | 13 (6.07)      | 23 (10.74)      |
| Associated bone fractures         | 17 (7.94)     | 15 (7.02)      | 32 (14.96)      |
| Patients with 1 comorbidity       | 0 (0.00)      | 1 (1.65)       | 1 (1.65)        |
| Patients with 2 comorbidities     | 8 (13.11)     | 10 (16.39)     | 18 (29.50)      |
| Patients with 3 comorbidities     | 22 (36.06)    | 20 (32.79)     | 42 (68.85)      |

Data are expressed in absolute value.

During surgery, the number of femoral head impacted, or visible subcortical hematoma or loss of articular cartilage greater than 50%, was of 18 patients out of 30 in the THA group, and 20 out of 31 in the ORIF group ( $P > 0.05$ ) (Table 3).

The IU RBCC preoperatively transfusions in both groups were

similar on average of 2.4 IU (range: 2–4), and there was a statistically significant difference (Table 3) as per IU RBCC postoperatively on average of 3.1 IU (2–6) for THA and 3.2 IU (2–6) for ORIF. There was a  $P < 0.05$  for the THA group against the POSTORIF group, who had received about 2.9 IU (range 2–6) transfusion (Table 3).

Patients of both groups were able to flex more than 90 degrees in the hip at 21 days after surgery and also to sit.

The average time for verticalization for the THA group (Figure 1) with total progressive load was allowed on average of 50.6 days (range: 45–60) from the trauma, instead of 92.4 days in the ORIF group (range: 75–110). There was a  $P < 0.05$  in favor of the THA group (Table 3).

There were no perioperative complications in both groups during hospitalization. There were 3 complications (1 seroma, 1 resolved external popliteal sciatic nerve paralysis, 1 wound dehiscence in the first 3 months after surgery in the THA group (Table 3) and 1 death at 8 months after surgery for a massive myocardial infarction of a patient who had resumed his normal daily activities. In the ORIF group, instead, there were 2 complications in the first 3 months after surgery (2 Morelli-Lavalle's hematoma, both posterior), 1 death at 14 months after surgery, 8 femoral head necrosis (Figure 2), and 15 ipsilateral osteoarthritis within the first year after surgery (Figure 2). The  $P < 0.05$  was in favor of the THA group (Figure 3). At this time, there were no postoperative complications in the POSTORIF group.

All 23 patients have returned to our centers to undergo hip replacement on fracture outcomes and at this time no one had postoperative complications.

The average HHS before the injury in the THA group was 81.3 points (range: 72–96), while it was greater in the ORIF group [83.4 (range: 72–96)] with a  $P > 0.05$  between the two groups (Figure 4). At the time of the trauma, both groups had, on average, a serious loss of functionality ( $P > 0.05$ ). At the second month post trauma for the THA group, the average HHS was 23.4 points (16–42) while for the ORIF group was 23.6 (16–42) ( $P > 0.05$ ). From the third month post trauma, it showed a  $P < 0.05$  in mean HHS scores in favor of the THA group (Figure 4). At the third month, there were 56.3 points (range: 42–74) of the THA against 44.2 points in the ORIF (28–68), while at the sixth month, the average HHS was 67.8 points (58–82) in the THA, and 63.5 (52–76) in the ORIF. Finally, one year after the trauma, the average HHS was 78.1 (66–92) in the THA and 70.2 (62–90) in the ORIF.

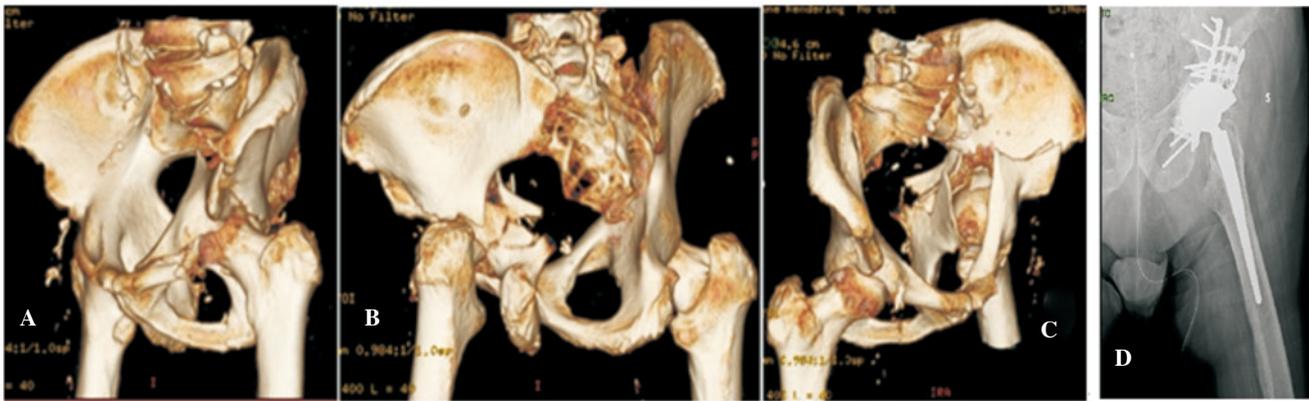
The average SF-12 before the trauma, in the THA group, was 84.6 points (range: 80–100), while it was higher in the ORIF [85.3 (range: 80–100)], with a  $P > 0.05$  between the two groups (Figure 5). At the time of the trauma, both groups had, an average, a severe loss of quality of life ( $P > 0.05$ ). The first month post trauma in the THA

**Table 3**

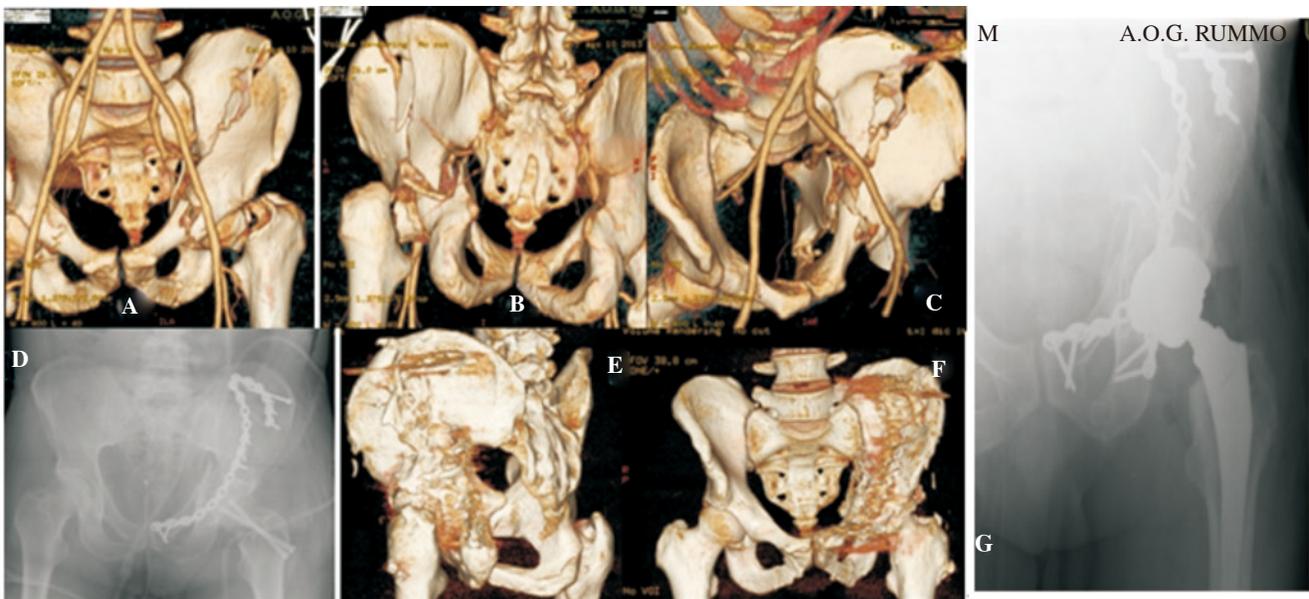
Operation results among the 3 groups taken into account. With hindsight the THA group had the best statistically significant results.

| Results  | THA  | ORIF   | POSTORIF                        |
|--|--|--|---------------------------------|
| Average hospitalization days (range)                                 | 16.7 (10–21)**   | 16.3 (10–22)                                   | 16.3 (10–22) + 7.3 (5–10)       |
| Average anesthesia time in minutes (range)                           | 215.6 (180–267)**  | 242.5 (165–210)                                | 242.5 (165–210) + 82.3 (62–103) |
| Numbers of patients with femoral head or joint injuries              | 18/30  | 20/31  | Not determined                  |
| Average IU RBCC transfused before surgery (range)                    | 2.4 (2–4)  | 2.4 (2–4)                                      | Not determined                  |
| Average IU RBCC transfused after surgery (range)                     | 3.1 (2–6)**  | 3.2 (2–6)                                      | 3.2 (2–6) + 2.9 (2–6)           |
| Average verticalization time in days (range)                         | 50.6 (45–60)*  | 92.4 (75–110)                                  | Not determined                  |
| Number of complication during the first three months postoperatively | One seroma;<br>One resolved EPS paralysis;<br>One wound dehiscence | Two Morelli-Lavalle's hematoma, both posterior | None***                         |

EPS: external popliteal sciatic nerve; \*: Statistically significant difference between THA and ORIF group ( $P < 0.05$ ); \*\*: Statistically significant difference between THA and POSTORIF group ( $P < 0.05$ ); \*\*\*: Statistically significant difference between POSTORIF and THA ( $P < 0.05$ ).

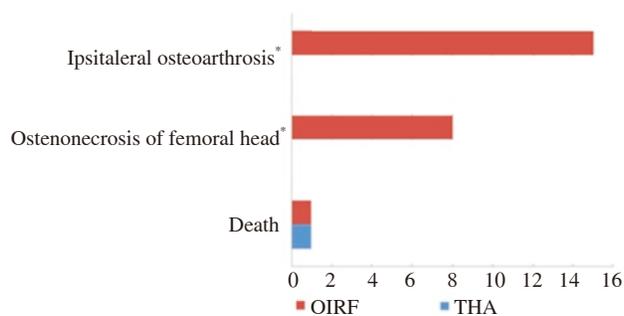


**Figure 1.** The 3D-CT shows a fracture of the left acetabulum (the direct trauma of the left hip was due to a bicycle fall) in a 83 year old patient. A: Anterior column with fractured ischio-pubic and ileum-pubic branches; B: Fractured posterior column and wall; C: Multi-fragmentation of the quadrilateral lamina multi-fragmentation of the quadrilateral plate and protrusion of the femoral head; D: At 3 months from the surgery, the X-ray showed the perfect consolidation of the acetabular fracture by the combined osteosynthesis with plate-wires and THA implanted with posterolateral approach with patient in the lateral decubitus position.



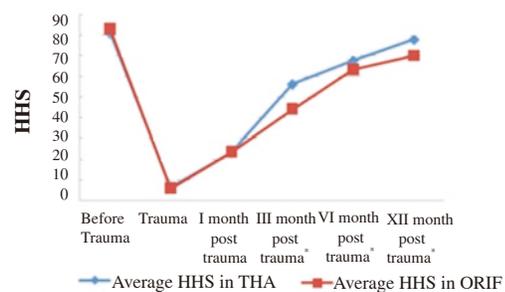
**Figure 2.** After falling from building slip, a 68-year-old man has come in Emergency. A, B and C: The 3D-CT shows bicolumn fracture of the acetabulum and the trans-cervical fracture of the femoral neck; D: The post-operative X-ray shows the great reduction of the acetabular fracture and good synthesis of the femoral head; E and F: One year after the trauma, the 3D-CT shows marked osteoarthritis no signs of avascular necrosis of the femoral head. G: Postoperative X-ray control displays the correct hip replacement implant.

**Complications after 3 months from the surgery**



**Figure 3.** Numbers of complications after 3 months postoperatively in the THA and ORIF group. \*:  $P < 0.05$  was in favor of THA group except in the category of deaths.

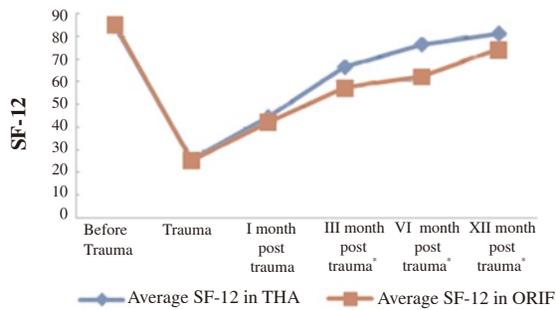
group, the SF-12 average was 44.3 points (36–76), while in the ORIF it was 42.3 (36-76) ( $P > 0.05$ ). From the third month post trauma, there was a  $P < 0.05$  in the SF-12 average scores in favor of the



**Figure 4.** Performance of HHS pre and at 1 year after the traumatic event. The THA group had a better functional recovery than the ORIF group. \*:  $P < 0.05$  was in favor of THA group.

PTA group (Figure 5). The third month showed 66.5 points (range: 48–88) in the PTA against 57.3 points (range: 44–76) in ORIF, while at the sixth month post trauma, the average SF-12 was 76.5 points

(58–92) in the PTA, and 62.3 (52–76) in the ORIF, and finally, one year after the trauma, the average SF-12 was 81.2 (66–96) in the PTA and 74.2 (56–92) in the ORIF group.



**Figure 5.** Performance of SF-12 pre and at 1 year after the traumatic event. \*: The THA group had a better recovery of the quality of life than the ORIF group.

#### 4. Discussion

In 2010, Ferguson *et al.*[3] showed that acetabular fractures were significantly more frequent in older men. This is in contrast with common fragility fractures such as hip and distal radius, which have a higher incidence in women[8]. Furthermore, the same Ferguson *et al.*[3] showed that in the elderly there was an increased preponderance of anterior column fractures, anterior wall and anterior column and posterior wall secured at a transverse as to young adults. In the elderly, fractures due to displacements of the anterior column (anterior column, the posterior wall with the rear and rear transverse associated with both the front wall and column) were commonly associated with the interruption of the quadrilateral blade, an impact lesion of the medial acetabular roof, an antero-central impact dislocation of the femoral head, an impact lesion of the femoral head. The posterior fractures tended to be comminuted and associated with the presence of intra-acetabular fragments and posterior hip dislocation[3]. In all age groups, the best predictor of ORIF success is the quality of the reduction[9,10]. Pagenkopf *et al.*[2] reported the possibility of anatomically reducing 96% of the simple fractures, but only 64% of the associated fractures (Letournel classification). Pagenkopf *et al.*[2] observed that their rate of anatomical reduction decreased significantly if the surgery is delayed more than 11 days after the trauma. So, this surgery must be done in an environment where multidisciplinary capabilities of the staff allow an early surgery to address these lesions[2]. In a meta-analysis[11] (made up of seven studies with 685 patients of all ages), the incidence of post-traumatic arthritis following a satisfactory reduction (< 2 mm) was 13.2%. If the reduction was not satisfactory (> 2 mm), this increase was 43.5%. However, the factors that influence the quality of the reduction include the type of fracture, fracture characteristics (comminution, occlusion), the time of surgery and the experience level of the operating team[11]. In the literature, many authors show that the dislocation of the femoral head for the removal of intra-articular fragments or repair of fractures of the femoral head is not predictive of head osteonecrosis[12,13]. In fact, the osteonecrosis may be due to the femoral head impact[14,15]. The post-traumatic arthritis, despite the early hip mobilization, is greater in the elderly than in young patients[3]. Moreover, all the complications seen in the ORIF group are found in the literature[16] as well as those in the THA group[17]. The poor bone quality of the osteoporotic bone

and the subchondral hematoma make the anatomical reduction very difficult[18]. Many surgeons are very restrictive in granting early mobilization of the hip and the load, convinced that older patients would not follow the prescribed therapy[18]. There is little in the literature suggesting good results with the fixation of the acetabular fracture in the elderly[18]. So, it is very important to evaluate the algorithm proposed by Pagenkopf *et al.*[2] for the treatment of associated acetabular fractures in the elderly (Letournel classification). The immediate decision to undertake in acute of prosthesis in an acetabular fracture must take into consideration two main factors: the own patient's complications of a reduction and synthesis can be so frequent as to make the surgery useless; or the patient already has such a framework of joint degeneration to consider prosthetization the solution for both problems, acetabular fracture and arthritis. The average hospital stay for THA and ORIF patients, considering the comorbidities and the type of fracture, was not very long and even the operation was performed in the first possible window of opportunity[19]. There was a longer surgical time in the ORIF procedure with dual approach compared to the THA group, due to the time of rolling of patients for the change of decubitus, and to set up the new operating field. The statistically significant difference with POSTORIF group is also due to the sum of the time and also, even to the difficulties encountered in making arthroplasty of the acetabular fracture treated with ORIF. In fact, the presence of the means of synthesis brings with it two problems: the first is linked to the possible conflict of the screws both during the preparation and during the insertion into the acetabulum; the second is related to the lower resistance to possible bacterial colonization, perhaps already present before the surgical act[20]. Compared to the study of Moushine *et al.*[21], all acetabular fractures in the THA group had a consolidation, but in 87% of the patients there was an early migration of the acetabular prosthetic implant. Nowadays, with modern protrusion cages, the semielliptical cups, the mobility and the new double-coated hydroxyapatite femoral stems, the implant failure is very difficult, if not rare. Moreover, this implant can have a long life as a primary THA osteoarthritis implant[22-27]. In the literature, it is shown that the prosthesis in acetabular fracture outcomes has a higher bleeding compared to THA and ORIF in acute trauma[1,28]. From the qualitative point of view of the hip function and the life, the patients were given two questionnaires: the HHS and the SF-12. As shown in the new study by Dettoni *et al.*[29], the validation to adaptation of the Italian population to the HHS, HHS, and SF-12 is correlated with each other. A recent study by Tosounidis *et al.*[30] shows that the quality of postoperative reduction was associated with HHS ( $P = 0.015$ ) and postoperative arthritis ( $P = 0.010$ ). A strong association was evident between age and postoperative reduction ( $P = 0.010$ ) and arthritis ( $P = 0.014$ ). The presence of the quadrilateral plate shattering and "Seagull" radiographic sign has been associated with poor postoperative reduction ( $P = 0.016$ ) and a low HHS score ( $P = 0.049$ ), respectively. These results on a large sample of patient population show how prosthesis in acute from both a physiological and qualitative view of life is higher in THA than ORIF. Acetabular fractures in the elderly, particularly those classified by Letournel as associated, can be complex to treat surgically and their management requires a multidisciplinary approach. There is a lack of consensus with respect to methods of treatment for the acetabular fractures in the elderly, but there is general agreement on the need for verticalization and early mobilization of the patient, aimed at restoring the pre-trauma functional reserve and reducing

complications in the short and long term. From the data available in the literature and those observed in our study, we can say that the treatment in the first instance of the associated acetabular fractures in the elderly, following the THA group directions, may be the procedure of choice. In fact, this method offers many advantages: single open sky surgical approach, acceptable surgical time, modest hospitalization time, early mobilization in the short term, and in the long run, a significant reduction of the possible complications related to trauma and surgical technique and therefore a lower risk of being reoperated.

### Conflict of interest statement

The authors report no conflict of interest.

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