Ceramic-on-ceramic total hip replacement: can different head sizes affect the clinical results?

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Background

It is important to ensure a hip replacement that has no complications and lasts for a reasonable length of time especially in young active patients. The ideal articulation should have good lubrication with minimal wear, should be hard enough to resist fractures, and should be highly biocompatible and available in different head sizes. The use of ceramics as bearing surfaces has had a long and successful history. Ceramic-on-ceramic (C.o.C) is a very wear-resistant, versatile articulation with different neck lengths and head diameters (28–32 mm, with large ceramic heads with a diameter of 36–40 mm now available).

Aim

The aim of the study was to investigate a possible effect of different ceramic head sizes on early clinical results in patients treated with C.o.C total hip replacement (THR), with special concern on postoperative hip range of motion (ROM) and stability.

Patients and methods

This study included 40 cases in 35 patients with end-stage arthritis. All cases were treated with C.o.C THR. Cases were divided into three groups according to the size of the ceramic head. Group I included 13 cases with 28-mm heads. Group II included 12 cases with 32-mm heads. Group III included 15 cases with 36-mm heads. Results were assessed according to the Harris Hip Score (HHS).

Results

There was significant improvement in the HHS at 6 weeks postoperatively in all the three groups compared with the preoperative HHS; this improvement became much more significant at 6 months postoperatively. At 6 weeks postoperatively, there was a statistically nonsignificant difference in the mean postoperative hip ROM scores between group I and group II cases and also between group II and group III cases, whereas there was a statistically significant difference in the mean postoperative hip ROM scores only between group I and group III cases. At 6 months postoperatively, the difference in mean postoperative hip ROM scores between all the three groups of cases became statistically nonsignificant. Although dislocation occurred in only one case (representing 2.5% of all the studied cases) with a 28-mm head, no sharp correlation between the head size and dislocation was detected.

Conclusion

Increasing the head size can safely improve the ROM especially in the early postoperative period but the term 'large head' could be a relative or a nonspecific term when considering the clinical (true) but not the technical (theoretically possible) ROM or if the relation between the head diameter to the size of the ceramic liner/cup construct and the head/neck ratio are not considered. The head size is critical for stability in THR but dislocation is multifactorial. Although C.o.C articulation is a marvelous bearing surface for young active patients, especially women in the child-bearing period, the 36-mm heads could not be used in most female cases (being restricted by the size of the native bony acetabulum), and therefore male patients have a better scope of being treated with 36-mm heads.

Keywords:
could improve stability, different head sizes, improved hip motion

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Introduction

Total hip replacement (THR) is the most effective treatment for end-stage arthritis of the hip joint. The goal of the new bearing surfaces is to extend implant life by markedly decreasing the amount of wear debris

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generated, thus considerably reducing or even eliminating osteolysis and loosening [1]. Ceramic-bearing surfaces represent the most significant advances in THR surgery because of the rapid and continuous improvements in manufacturing techniques and tribological behavior.

In-vitro wear studies have proved that ceramic-on-ceramic (C.o.C) is a very low-friction couple with better wettability with body fluids and superior wear properties (~5000 times less) when compared with other bearing surfaces such as metal-on-polyethylene (with the reported risks of polyethylene wear debris-induced osteolysis and/or loosening of the prosthesis with accompanying pain and disability) and metal-on-metal articulations, with concerns related to the elevated serum levels of metals, especially cobalt and chromium [2].

Ceramic-bearing surfaces in THRs were originally introduced as pure alumina (Al_2O_3) material [3], which then underwent substantial improvements to result in a hot isostatically pressed (HIPed) alumina (BIOLOX-forte, CERAM TEC. AG, Germany) [4]. The latest developments in ceramics have taken advantage of the superior properties of alumina and zirconia materials to create an alumina matrix composite (BIOLOX-delta) [5]. This material, which is also known as zirconia-platelet-toughened alumina, is composed of 75% alumina, 24% zirconia, and 1% oxides [6]. Alumina matrix composite material (BIOLOX-delta) has improved mechanical properties over standard alumina, with bending strength improved by 210%, burst strength improved by 160%, and fracture toughness improved by 150% [7]. This innovation has extended the design flexibility of the C.o.C bearings by allowing the production of larger-sized femoral heads [2].

Instability and dislocation after THR always represent an annoying concern. The dislocation rate in THR in the literature consistently ranges between 1 and 10%. Fifty percent of patients with postoperative dislocation will experience iterative recurrence, leading to revision surgery [8].

With articulations having small diameter heads, a higher probability of impingement, subluxation, or dislocation exists. Implants with larger head diameters have been developed to limit the risk of dislocation [8].

Increasing head diameter increases the head/neck ratio, delaying neck/cup contact and thus extending implant range of motion (ROM). Moreover, the jumping distance is increased, allowing greater ROM before true dislocation occurs [9]. It is also clear that the 'bigger' the diameter of the implant head, the greater the 'tolerance' with respect to other dislocation factors due to the reduced risk of cam effect [10].

Patients and methods

This study was conducted in the Orthopedic Department of Benha University Hospital. It included a retrospective and a prospective component. The retrospective part presented and analyzed the results of a previous study conducted between April 2009 and May 2012, which included 15 cases with end-stage arthritis that were treated with C.o.C THR, with a 28-mm head used in 13 cases and a 32-mm head used in two cases [11].

The procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 and 2008.

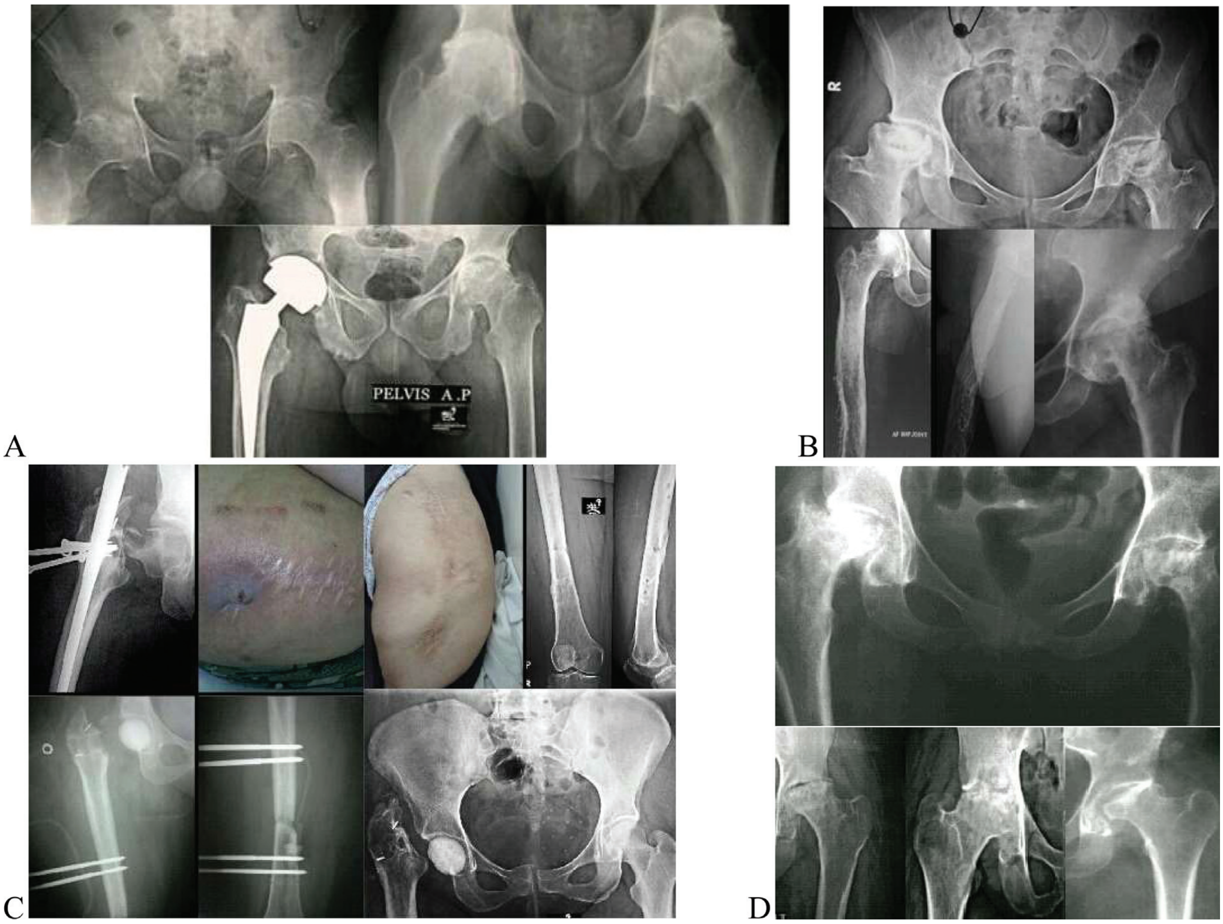
All patients gave informed consent before inclusion in the study; the study was authorized by the institutional review board.

The prospective part was carried out between October 2012 and December 2014 and included 25 cases. Thirty-two millimeter heads were used in 10 cases, whereas 36-mm heads were used in 15 cases. Each hip was considered a separate case (30 patients had unilateral affection, whereas five patients had bilateral affection). There were 22 female (representing 55% of the studied cases) and 18 male (representing 45% of the studied cases) patients. Their ages ranged from 19 to 56 years, with a mean age of 33.63 ± 9.25 years.

The underlying pathology was varied (Fig. 1). In 26 cases, the cause of arthritis was avascular necrosis. Seven cases had ankylosing spondylitis and six cases had systemic lupus erythematosus (SLE). There was one case with excision arthroplasty performed for treatment of an infected nonunited iatrogenic fracture neck of the femur (during fixation of a closed femoral shaft fracture with interlocking nail) after complete eradication of infection (clinically and serologically), secure union, and full consolidation of the original femoral shaft fracture.

Preoperative evaluation started with complete history, physical examination, and scoring of patients' condition according to the Harris Hip Score (HHS) [12].

Figure 1



The underlying pathology in some of the presented cases. (a) Examples of cases with A.S. (one patient was previously treated with metal on metal THR). (b) Examples of cases with A.V.N. (one patient had epsilateral old healed osteomylitis femur). (c) The case with excision arthroplasty for infected non-united iatrogenic fracture neck femur during fixation of a femoral shaft fracture with interlocking nail. 6 months later, the fracture was united on external fixator with eradication of infection. After another 6 months, it was ready for a challenging hip replacement after Girdlestone's procedure with about 5 cm of shortening and deficient abductors. (d) examples of cases with S.L.E. (with severe head erosion and corticosteroids-induced osteoporosis).

Laboratory and radiological evaluation and planning were done. Prophylactic intravenous antibiotics were started the day before surgery and the procedure was performed under spinal anesthesia in all cases. The posterior approach was adopted in eight cases (20% of the studied cases) and the lateral approach in 32 cases (80% of the studied cases).

In all cases, a totally cementless C.o.C THR was done. The critical step was to achieve initial stability in both components to pave the way for a reliable and durable secondary stability through osteointegration. Press-fitted stems and cups (with or without additional screws) guarantee early partial weight-bearing from the first postoperative day until allowing full weight-bearing after 6 weeks.

Thromboembolic prophylaxis was combined with intravenous third-generation cephalosporins for 7 days postoperatively and was then replaced with oral clindamycins for another 7 days.

Cases were divided into three groups according to the head size. Group I included 13 cases (12 women and one man) with 28-mm ceramic heads. Group II included 12 cases (nine women and three men) with 32-mm ceramic heads. Group III included 15 cases (one woman and 14 men) with 36-mm ceramic heads.

Postoperative radiological and clinical evaluation was done and repeated at regular follow-up visits at 6-week intervals in the first 6 months after surgery, then every 3 months until the first year and then annually. Statistical analysis was performed using a two-tailed Student's t-test. P value less than 0.05 was considered significant.

Results

The duration of follow-up ranged from 18 to 58 months (mean: 28 months). The clinical results in this study were evaluated according to the HHS [12]. Radiological evaluation included assessment of cup position in relation to the hip center of rotation and teardrop, cup version, cup abduction angle in relation to the interteardrop line or the interischial line, stem position, and limb length discrepancy.

Clinical results

HHS, the widely accepted and comprehensive scoring system, was used for clinical evaluation of patients preoperatively and postoperatively at 6 weeks, 6 months, and yearly thereafter until the last follow-up. The score is considered excellent if it is between 90 and 100, good if between 80 and 90, fair if between 70 and 80, and poor if below 70. The preoperative HHS ranged from 22 to 44, with a mean of 32.6 ± 10.47. The postoperative HHS in the last follow-up ranged from 84 to 96, with a mean of 92.3 ± 14.5. There was statistically significant difference ($P < 0.001$) between the mean preoperative HHS and the last follow-up HHS (Table 1).

Excellent results (HHS≥90) were obtained in 38 cases, representing 95% of the studied cases, and good results (HHS: 80–90) were reported in two cases, representing 5% of the studied cases. No cases were rated either fair or poor. Therefore, satisfactory results (excellent and good results) were obtained in all cases (Figs 2a, c, and d and 4a–c).

Special attention was given to the postoperative ROM. ROM score accounts for five points in HHS. There was a statistically significant difference between the mean preoperative ROM score and the postoperative mean ROM score at 6 months in all the studied groups of cases (Table 2). There was a statistically nonsignificant difference in the mean 6-week postoperative hip ROM score between group I and group II cases and also between group II and group III cases, but a statistically significant difference between the mean postoperative hip ROM score only between group I and group III cases (Table 3).

Table 1 Mean preoperative Harris Hip Score compared with the mean last follow-up Harris Hip Score

HHS	Preoperative HHS	Last follow-up HHS
Mean ± SD	32.6 ± 10.47	92.3 ± 14.5
P-value	<0.001	

HHS, Harris Hip Score. *P*, significant difference between preoperative HHS and last follow-up HHS.

Although there was a highly statistically significant difference in the mean preoperative ROM score and the mean 6-month postoperative ROM score in all groups (Table 2), the difference in the mean postoperative hip ROM score between all the three groups at 6 months postoperatively became statistically nonsignificant (Table 4).

In three cases in which the cause of hip affection was inflammatory arthritis (SLE) there was clear discharge with no pain or fever; this discharge was sterile. Stitches were removed in the third week, not as usual after 15 days, with completely healed scars. This could be due to corticosteroid therapy and abnormal fat metabolism. In one case, superficial infection occurred in a diabetic female patient that was improved with a course of intravenous antibiotics and good control of blood sugar levels. Only repeated dressing with pure alcohol was needed.

Dislocation due to a traumatic event 7 months after surgery occurred in one case with SLE (representing 2.5% of the studied cases). She was operated upon following the posterior approach and a 28-mm ceramic head was used.

Reduction was done under general anesthesia and the patient was kept in bed in abduction brace for 3 weeks. She regained her predislocation ROM with excellent functional outcome with no history of redislocation until the last follow-up. Squeaking occurred in two cases (representing 5% of the studied cases) and they were managed with reassurance.

Radiological results

Standard radiographs were taken for all patients immediately postoperatively and at subsequent follow-up visits (Fig. 2).

Acetabular component

Acetabular inclination was determined in relation to the interteardrop line. Acetabular inclination in all cases

Table 2 Preoperative range of motion score compared with the 6-month postoperative range of motion score

	Groups					
	Group I		Group II		Group III	
	Preoperative ROM score	6-Month postoperative ROM score	Preoperative ROM score	6-Month postoperative ROM score	Preoperative ROM score	6-Month postoperative ROM score
Mean ± SD	1.9 ± 0.48	4.08 ± 0.76	2.2 ± 0.64	4.3 ± 0.79	2.2 ± 0.57	4.45 ± 0.63
P	<0.001	<0.001	<0.001			

ROM, range of motion. *P*, significant difference between preoperative ROM score and 6-month postoperative ROM score in all groups.

Figure 2

The radiological and clinical results of some of the studied cases. (a) A case of A.S. treated successively with 36 mm head C.o.C hip replacement through the posterior approach with good radiological and clinical result. (b) 3 different cases treated with 36 mm head C.o.C hip replacement with good radiological result, (the right upper case was not included in this study as it was previously replaced with metal on metal hip replacement). (c) The case of excision arthroplasty treated with 32 mm head C.o.C hip replacement, through the lateral approach with good clinical result (ROM, stability, restoration of length) completely healed femoral fracture. A well seated and integrated cup with restoration of the hip centre. Well integrated Stem although in a slight varus position. (d) A case of A.V.N in a 19 years old married female with 32 mm head C.o.C hip replacement through the lateral approach with good radiological and clinical result of the operated side compared to the other affected left hip.

Table 3 Six weeks postoperative hip range of motion score

	Groups (6 weeks mean postoperative ROM score)		
	Group I	Group II	Group III
Mean ± SD	2.9 ± 0.1	3 ± 0.1	3.1 ± 0.2
P_1	NS		
P_2		NS	
P_3	<0.01		

ROM, range of motion. P_1, nonsignificant difference between group I and group II. P_2, nonsignificant difference between group II and group III. P_3, significant difference between group I and group III.

Table 4 Six-month postoperative hip range of motion score

	Groups (6-month mean postoperative ROM score)		
	Group I	Group II	Group III
Mean ± SD	4.08 ± 0.76	4.3 ± 0.79	4.45 ± 0.63
F	NS		

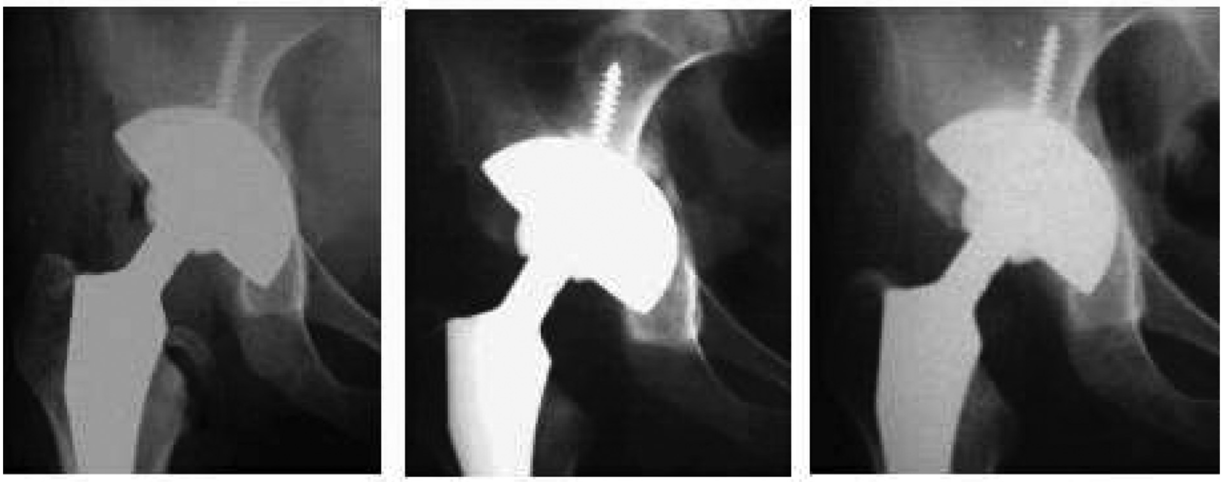
ROM, range of motion. F, nonsignificant difference in the 6-month postoperative range of motion score between all groups.

ranged from 42° to 67°, with a mean of 45.8 ± 1.78°. All cups were placed in the normal hip center, except in one case with SLE because of superior acetabular erosion.

All cups were seated close to the acetabular teardrop and completely covered by the outer bony rim of the acetabulum, except in one case (representing 2.5% of the studied cases) with slightly lateralized cup due to improper removal of a large medial osteophyte.

In one case, an intraoperative crack occurred around the acetabular component (Fig. 3) due to improper reaming and acetabular preparation.

Figure 3



Progression of healing of an iatrogenic acetabular fracture due to improper acetabular preparation with no position change of the cup (Day-1, 6 weeks post-operatively and 3 months post-operatively) [11].

Cup version could roughly be estimated in both the anteroposterior and lateral view plain radiographs. The cup was slightly retroverted in three cases (representing 7.5% of the studied cases) and excessively anteverted in one case (representing 2.5% of the studied cases).

Femoral stem alignment

Simply, if the tip of the stem is central, it is in neutral alignment. If the tip is pointed or resting on the lateral cortex it is in varus alignment and if the tip is pointed or resting on the medial cortex it is in valgus alignment. All stems were in neutral position (central) except in three cases (representing 7.5% of the studied cases); it was in valgus position in two cases and in varus position in one case. Only two cases (representing 5% of the studied cases) had limb length discrepancy of about 0.5 cm.

Until the last follow-up:

(1) there were no reported cases with early osteolysis or loosening of either component;
(2) there were no reported cases with heterotopic ossification;
(3) there were no reported cases with stem position change or migration;
(4) there were no reported cases with cup rotation or migration or broken screws;
(5) there were no reported cases with broken ceramic heads or liners.

In the case with intraoperative periacetabular crack, there was complete union and remodeling of the fracture 3 months after surgery with no position change of the cup until the last follow-up, and the patient was satisfied (Fig. 3).

Discussion

Despite the limited number of cases in this study, analyzing and discussing the presented results could give answers to some important questions such as: Why use C.o.C bearings? Can C.o.C hips extend the spectrum of candidates for hip replacement? Is head size the only factor in hip stability? Can different head sizes markedly affect the ROM? Can the 36-mm ceramic head be used when needed in all cases? Is the term 'large head' a specific or a sharp term?

Why use ceramic-on-ceramic bearings? Can ceramic-on-ceramic extend the spectrum of candidates for total hip replacement?

The most common articulation used in THR is metal-on-polyethylene; however, with polyethylene components, loosening of the prosthesis and/or wear debris-induced osteolysis with accompanying pain and disability is very common. Nowadays, efforts to improve the survival of total hip arthroplasty implants have focused on alternative bearing surfaces in order to decrease wear and osteolysis [13].

With young and more active patients undergoing hip replacement, hard-on-hard bearings such as metal-on-metal and C.o.C bearings can be used.

With metal-on-metal articulations, many concerns related to elevated serum metal ion levels, such as persistent pain due to hypersensitivity to metal ions, and metal ion carcinogenicity, have been expressed. Many surgeons elect not to perform metal-on-metal bearing in women in child-bearing age. Renal impairment is a contraindication for metal-on-metal hip replacement.

C.o.C is a good alternative with minimal wear in such situations. Refinements in the ceramic manufacturing process and improvements in component design have greatly reduced material-specific complications such as component loosening and ceramic fracture [14].

In this study, the mean age of all cases was 33.63 ± 9.25 years, with female patients representing 55% of the studied cases (Table 5). C.o.C bearings can be safely used in young active patients with hypersensitivity to metal ions or with renal impairment. Women in the child-bearing period are ideal candidates for C.o.C THR. Hence, C.o.C THR can safely extend the spectrum of candidates for THR.

Table 5 Characteristics of the presented cases

Groups	Cases	Age	Sex	Underlying pathology	Head size	Cup size	Approach used	Complications
I	1	39	Female	AVN	28	46	Lateral	No
	2	24	Female	SLE (on corticosteroids)	28	54	Lateral	Intraoperative acetabular crack, clear sterile wound discharge for 2 weeks
	3	24	Female	SLE (on corticosteroids)	28	48	Lateral	No
	4	29	Female	SLE	28	48	Posterior	Dislocation once
	5	28	Female	AVN	28	46	Lateral	No
	6	48	Female	AVN	28	48	Lateral	No
	7	33	Female	SLE (on corticosteroids)	28	46	Lateral	Clear sterile wound discharge in the first week
	8	24	Female	AVN	28	48	Lateral	No
	9	39	Male	AVN	28	50	Lateral	No
	10	33	Female	AVN	28	52	Lateral	No
	11	26	Female	AVN	28	46	Lateral	No
	12	25	Female	AVN	28	48	Lateral	No
	13	47	Female	AVN	28	48	Lateral	No
II	14	19	Female	AVN	32	50	Lateral	Squeaking noisy sound
	15	38	Female	AVN	32	48	Lateral	No
	16	40	Female	AVN	32	50	Lateral	No
	17	28	Female	AVN	32	48	Lateral	Infrequent thigh pain
	18	23	Female	AVN	32	48	Lateral	No
	19	44	Female	AVN	32	50	Lateral	No
	20	30	Female	AVN	32	48	Lateral	No
	21	56	Male	AVN	32	52	Lateral	No
	22	33	Female (diabetic)	AVN	32	50	Lateral	Superficial wound infection
	23	38	Female	Ex. Ar.	32	50	Lateral	Squeaking noisy sound
	24	26	Male	AVN	32	52	Lateral	No
	25	41	Male	AVN	32	52	Lateral	No
III	26	50	Female	AVN	36	52	Lateral	No
	27	33	Male	AS	36	54	Posterior	No
	28	33	Male	AS	36	54	Posterior	No
	29	50	Male	AVN	36	56	Lateral	Infrequent thigh pain
	30	45	Male	AS	36	52	Posterior	No
	31	42	Male	AVN	36	56	Lateral	No
	32	37	Male	AS	36	54	Posterior	0.5 cm LLD
	33	37	Male	AS	36	54	Posterior	No
	34	25	Male	AS	36	56	Posterior	No
	35	25	Male	AS	36	56	Posterior	No
	36	26	Male	SLE (on corticosteroids)	36	54	Lateral	Clear sterile wound discharge in the first week
	37	26	Male	SLE	36	54	Lateral	0.5 cm LLD
	38	34	Male	AVN	36	56	Lateral	No
	39	27	Male	AVN	36	54	Lateral	No
	40	20	Male	AVN	36	56	Lateral	Infrequent groin pain
Mean ± SD	33.63 ± 9.25							

AS, ankylosing spondylitis; AVN, avascular necrosis; Ex. Ar., excision arthroplasty; LLD, limb length discrepancy; SLE, systemic lupus erythematosus.

Can head size be the only effective factor in hip stability?
Conventional 28 and 32-mm diameter alumina/alumina couples have displayed remarkable performance in terms of wear and debris biocompatibility [15]. This makes the 28 and 32-mm configuration a proven solution in terms of wear in young and/or active patients in whom a hard/hard couple is indicated [16]. Studies showed that, to improve stability significantly by increasing the head size, a diameter greater than 36 mm is needed [10].

An increased diameter with correct cup positioning reduces the risks of cam effect and of dislocation (4.5% for 28 mm vs. 1.8% for 36 mm) [17]. Increasing the head diameter increases the head/neck ratio, delaying neck/cup contact and thus extending implant ROM. Moreover, the jumping distance is increased, allowing greater ROM before dislocation occurs [9].

In an experimental study, Burroughs *et al.* [17] showed that diameters greater than 32 mm increased the ROM and reduced dislocation risk. Beaulé *et al.* [18] reported less than 10% recurrence after treatment of iterative dislocation using heads of 36-mm diameter or more. Mertl *et al.* [19] reported a 1.8% rate of dislocation with large-diameter metal-on-metal couples on a posterolateral approach.

In contrast, these encouraging results need to be taken with caution. Skeels *et al.* [20] reported 17% dislocation recurrence in patients who had undergone total hip replacement (THA) revision using a 36-mm head.

Clinical results for 36- and 40-mm head implants (polyethylene cup) in 61 (4.6%) patients at risk of dislocation showed no significant reduction in risk compared with previous series [21].

Although many high-quality studies have demonstrated the benefit of large femoral heads in reducing postoperative instability [22], head diameter itself is only partly responsible for the dislocation rate as the theoretical gain in stability obtained by using a large femoral head (above 36 mm) is negligible when there is a high cup abduction angle [9].

In this study, dislocation occurred in only one case (representing 2.5% of all the studied cases) 7 months postoperatively with a history of traumatic event (slipping). In this case, a 28-mm head was used. The surgery was performed through the posterior approach and the cup was slightly retroverted. Thus, dislocation could be due to any of the above factors or a combination of them. No one could definitively identify the cause of dislocation in this case. After closed reduction and 3 weeks in abduction brace, she regained her predislocation ROM with no history of redislocation or instability-related problems until the last follow-up with the same 28-mm ceramic head (Fig. 4a).

Compared with the case presented in Fig. 4a, a relatively larger head (32 mm) and the more stable lateral approach could compensate for a slightly retroverted cup, adding more stability and preventing dislocation (Fig. 4b).

Compared with the case presented in Fig. 4a, in Fig. 4c, although both cups were slightly retroverted and 28-mm heads were used through the posterior approach, stability was different. Restoration of soft-tissue tension and repair at the end of surgery in addition to the condition of the supporting muscles could also contribute to the stability of the prosthesis.

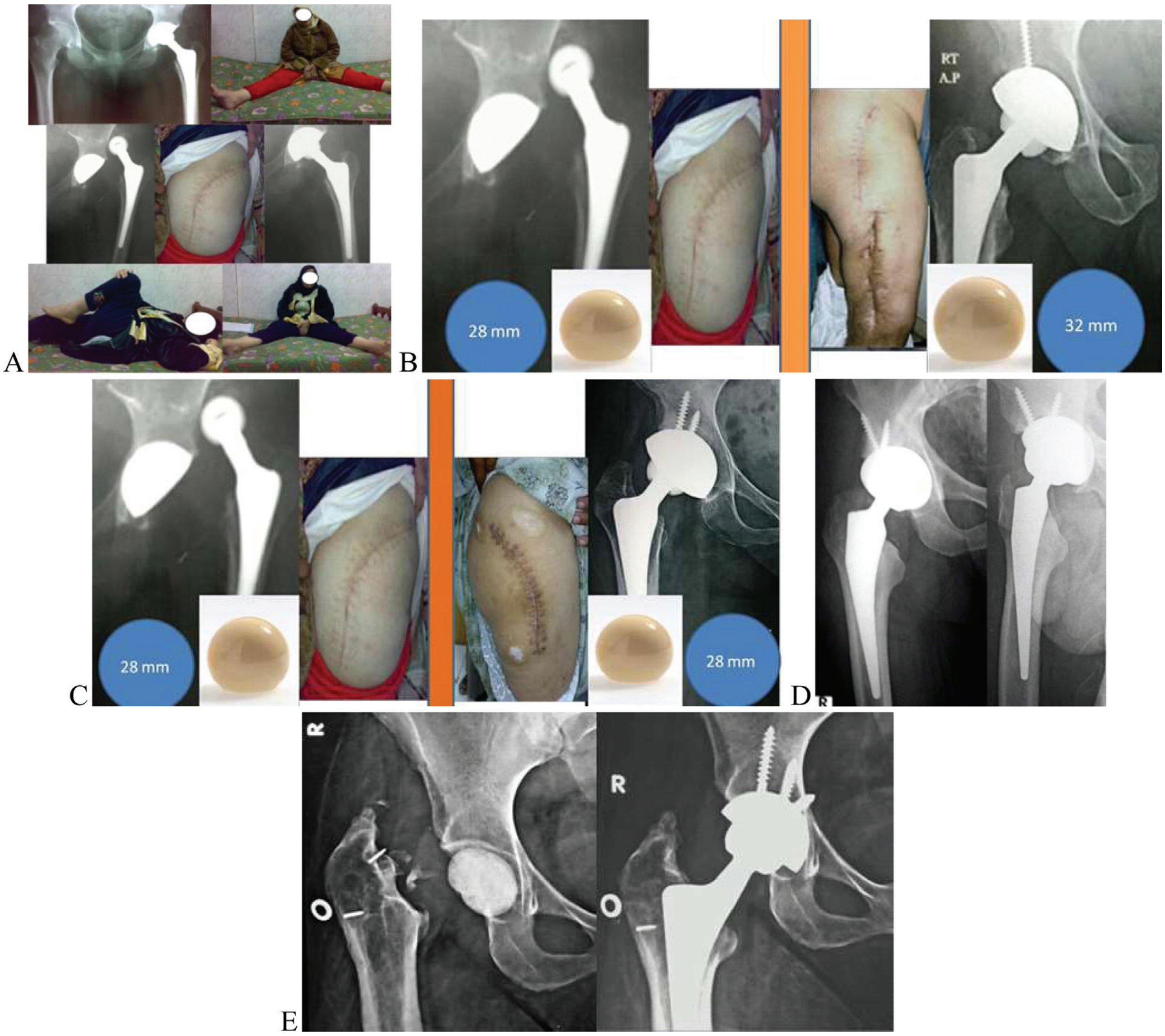
In another case presented in Fig. 4d with a 36-mm head, the acetabular component was excessively anteverted and this case was operated upon following the lateral approach. This situation could certainly endanger hip stability, especially in external rotation, with any traditional head size. Thanks to the large head (36 mm), this patient had no stability-related problems until the last follow-up.

In Fig. 4e, this case was treated with a 32-mm head through the lateral approach 12 months after Girdlestone's procedure with many predisposing and triggering factors for instability and dislocation (having undergone three previous hip surgeries, absent head for a long time after excision, deficient abductors, and proximal migration of the femur). She had excellent clinical results and stability until the last follow-up. Was the stability here due to the 32-mm head used or the lateral approach or due to a well-positioned cup in terms of inclination and version or due to all these factors working together?

I think this is a matter of significance. If it is only the head size that brings stability and prevents dislocation, how can we explain the success and stability of Charnley's hip replacement with a head diameter of 22 mm? How can we explain dislocation reported with some cases with resurfacing arthroplasty with head diameters more than 44 mm?

Although the head size is important in stability in THR, the improved stability provided by increased head size is dependent on cup orientation and is lost in case of malpositioning in abduction [23]. Thus, the head

Figure 4



(a) A female case with S.L.E treated with a 28 mm C.o.C hip replacement (11) through the posterior approach with good clinical result - for 7 months - till dislocation occurred. Closed reduction done and the patient regained her ROM and stability after 3 weeks bed rest in abduction brace. (b) No one can definitely identify the cause of dislocation in the case On the left side, Was dislocation occurred only because of the retroverted cup or the used posterior approach or the 28 mm head? Or all these factors were accused?. On the other hand, was stability in the other case due to the 32 mm head or the more stable lateral approach used or both factors could had compensated for a retroverted cup? (c) Both cases had slightly retroverted cups, operated through the posterior approach and a 28 mm head was used in both cases. What made the difference in the clinical results in these two cases?. Definitely, there are other factors that could be implicated in stability and had made the difference. (d) This case that was treated with a 36 mm C.o.C hip replacement through the lateral approach in a male patient with A.V.N with excessive cup ante-version detected in both X- ray views. Lateral approach with excessive cup ante-version could certainly endanger hip stability especially in external rotation. This patient had no stability related problems till the last follow-up mostly because of the 36mm head. (e) This case that was treated with a 32 mm C.o.C hip replacement through the lateral approach after 12 months of Girdlestone's procedure with proximal migration and deficient abductors (absent fulcrum and previous surgical trauma three times before replacement) with good clinical result and stability till the last follow-up. Was the stability here due to the 32 mm head or the lateral approach used or because of a well positioned cup regarding inclination and version? or because of all of the previous factors?.

diameter is not the only effective factor in hip stability, and dislocation is multifactorial, with many contributing factors that could be probably more important and critical than just increasing the head size.

Can different head sizes markedly affect the range of motion?

Impingement-free ROM is a good indicator of the clinical success of THR. Impingement in the prosthetic hip is both device and surgeon-dependent [24]. The device-related design factors are those that influence the femoral head–neck ratio as well as features of acetabular design. The surgeon can control the position of the cup with regard to inclination and version as well as its depth in the osseous acetabulum [25,26].

Head size directly influences the technical (theoretically possible) ROM. For example, increasing the head size from 28 to 36 mm yields an increase of 13° in the technical ROM (123–136°) [27].

The difference between the technical (theoretically possible) ROM and the true (clinical) ROM reflects the actual effect of increasing the head size on the overall gained ROM. Many other design variables such as the taper diameter and the cup entrance plane influence the ROM [28]. This 'true' ROM of the patient is heavily influenced by the orientation of the components, the muscular and soft-tissue condition.

Impingement can lead to subluxation or even dislocation of the hip joint. If impingement occurs frequently in positions within the required ROM for either daily or athletic activities needed by the patient, dislocation is probable [27].

The needed arc of motion during normal daily activities is about 124° flexion/extension, 28° abduction/adduction, and internal/external rotation up to 33° [27].

Analysis of the results of this study revealed that 6 months postoperatively there was nonsignificant difference in the mean ROM score between the three groups of cases.

Increasing the head size from 28 to 32 mm had a nonsignificant effect on the ROM in the first 6 weeks postoperatively. A nonsignificant difference in the mean ROM score was also seen between cases treated with 32-mm heads and those treated with 36-mm heads in the initial 6 weeks postoperatively, whereas increasing the head size from 28 to 36 mm improved the early ROM.

The difference in the mean postoperative hip ROM score between the three groups at 6 months postoperatively became statistically nonsignificant. Thus, clinically, any hip system that can enable the patient to safely perform activities within this range with no pain, instability, or dislocation could be considered an efficient hip whatever the head size used.

The underlying pathology and long-standing muscle contractures represent an important variable affecting the ROM of patients with THR. In this study, the least regained ROM was found in cases with ankylosing spondylitis in spite of the 36-mm heads used in these patients.

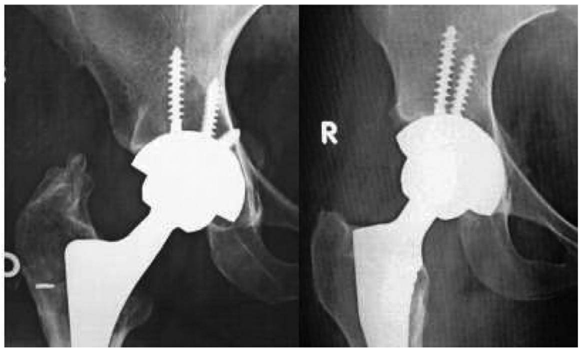
Can 36-mm ceramic heads be used in all patients?

In certain situations, where the patient is at high risk for dislocation, any weapon that can fight instability should be used.

Increasing the head size is a well-reported factor in stability improvement in hip replacement. The use of large heads with diameters of 36 mm or more necessitates the use of relatively large-sized liners inserted within larger metal shells (cups), which could be unsuitable in many patients, being restricted by the size of the native bony acetabulum. This condition is much more common in female patients as it is uncommon to find female patients whose bony acetabulum can accept cups of more than 50 mm diameter without violation of the medial wall of the acetabulum (Fig. 5) or being uncovered laterally by a bony rim of the native acetabulum to the extent that could affect stability and orientation of the cup.

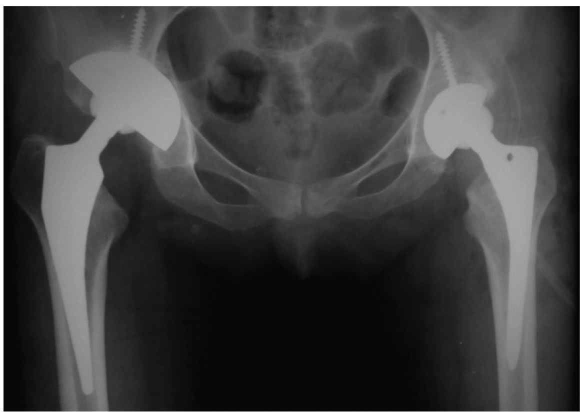
Of the 22 female cases studied, only one case was treated with a 36-mm head coupled with a ceramic liner in a 52-mm cup. All other female patients had cup

Figure 5



The largest cup size could have been inserted in these two female patients without violation of the medial wall was 50 mm that can just accept 32 mm ceramic heads being restricted by the size of the native bony acetabulum.

Figure 6



24 years old female with bilateral S.L.E on corticosteroids [11], a very large 54 mm cup was used in the right side with a 28 mm (BIOLOX-forte) ceramic head. With proper reaming and preparation of the left side, the same head was used in combination with a 48 mm cup.

sizes below 52 mm and were treated with either 28- or 32-mm heads. The 36-mm large head could not be used in all patients, especially in women, and therefore male patients have a better scope of being treated with ceramic heads with diameters of 36 mm or more.

Is the term large head a specific or a sharp term?

The head diameter should not be conceptualized as an isolated figure by neglecting its relationship to the liner inserted in a well-fixed metal shell (cup). A 28-mm head articulating with a ceramic liner in a 54-mm cup cannot mechanically be the same as a 28-mm head articulating with a ceramic liner in a 44-mm cup.

In contrast, a 36-mm head articulating with a ceramic liner in a 52-mm cup is different, mechanically, from the same 36-mm head articulating with a ceramic liner in a 66-mm cup. However, a 36-mm head is surely a large head compared with a 28-mm head when both are articulating with a ceramic liner inserted in a 52-mm metal shell.

The previous concerns may explain the condition of one of the early patients in this study with bilateral SLE on corticosteroids. A large-sized cup with a diameter of 54 mm was used on the right side with a 28-mm (BIOLOX-forte) ceramic head due to improper acetabular preparation and over-reaming. The same (BIOLOX-forte) 28-mm ceramic head was used in articulation with a 48-mm cup when operating the left side 6 months later. Nine months postoperatively, the total HHS of the left side was higher than that of the right side and the patient was more assured and satisfied with her left hip with respect to stability and ROM (Fig. 6).

Another example demonstrating that hip mechanics is more complex than a head size figure is resurfacing arthroplasty in which the head sizes are usually larger than 36 mm, the technical (theoretically possible) ROM is less when compared with that obtained with the same head size on a standard stem because of difference in head/neck ratio, and impingement occurs.

Thus, the term large head can be a relative or a nonspecific term if the relation of the head diameter to the cup/liner construct size and the head/neck ratio of the inserted prosthesis are not considered.

Finally, it is important to highlight the theoretical drawbacks of increasing the head size on the durability of the construct.

Head diameter impacts other variables, apart from joint stability, such as wear and cam-type impingement [29]. Progressive increase in head diameters is not a comprehensive answer for all difficult situations and is subject to certain reservations [10] such as subluxation, which could cause microseparations and edge loading.

Increased bone/cup interface stress correlated to friction may reintroduce the problem of acetabular fixation in cups receiving ceramic inserts. Insert rupture with reduced thickness is a distinct complication in insert fracture by malpositioning due to cone slope. Taken together, these concerns regarding the long-term reliability of larger head diameters may nullify the benefit expected from composite ceramics and oblige surgeons to use conventional diameters [30].

Conclusion

(1) C.o.C articulation is a marvelous bearing surface for young active patients, especially women in the child-bearing period.
(2) Increasing the head size from 28 to 36 mm safely improves the ROM in the early postoperative period (the first 6 weeks) once the other mechanical parameters of cup position, version, and offset are respected.
(3) Although the head size is critical to stability in THR, dislocation is a complex, multifactorial problem.
(4) Male patients have a better scope of being treated with C.o.C THR with 36-mm heads compared with female patients because of their relatively larger-sized bony acetabular sockets.
(5) The term large head can be a nonspecific term if the relationship of head size to its articulating liner/cup construct size and the head/neck ratio are not considered or when only the clinical (true) and not the technical (theoretically possible) ROM is considered.

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Conflicts of interest

There are no conflicts of interest.

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