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Retrospective Cohort Study

Outcome and revision rate of uncemented humeral head resurfacing: Mid-term follow-up study

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Abstract

BACKGROUND

Glenohumeral osteoarthritis (OA) is a common cause of pain and disability affecting nearly a third of the world's population over 60 years of age. As in other joints, shoulder arthroplasty appears to be the most effective treatment. The implant design has evolved during time transitioning to shorter humeral stem lengths or even stemless components.

AIM

To evaluate the medium-term outcome and survival of a cementless humeral head resurfacing (HHR) in a group of patients affected with OA or avascular necrosis.

METHODS

This is a retrospective study of prospectively collected data using HHR in 23 patients (15 female and 8 male) after a 7.4 year follow-up. The collected data included clinical and radiographical evaluation. The Constant score, the visual analogue scale, and a clinical evaluation of range of motion were registered pre- and postoperatively. Fifteen patients affected with OA (2 cases of mild, 6 moderate, and 7 severe) and 10 with avascular necrosis (stage III according to Cruess classification) were enrolled. X-rays were evaluated to detect loosening signs, degenerative changes, and superior humeral head migration. Magnetic resonance preoperatively was also performed to assess the rotator cuff status. Tendon integrity was mandatory to implant the HHR.

RESULTS

In total, 19 patients (21 shoulders) completed the follow-up. Data on 4 shoulders,

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in 4 patients, were lost because of prosthesis failure. The global revision rate was 16%. A statistically significant improvement in the mean Constant score, visual analogue scale, and range of motion have been reported. No signs of loosening were registered, while in 12 cases a glenoid erosion was found. The osteophytes appeared 7 times on the humeral side and 12 on the glenoid. Superior humeral migration was recorded in only 1 case.

CONCLUSION

HHR remains a reasonable option in patients with an intact rotator cuff for the treatment of OA and avascular necrosis.

Key Words: Shoulder; Arthroplasty; Humeral head; Resurfacing; Glenoid erosion; Prosthesis failure

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Core Tip: Shoulder arthroplasty is the most effective treatment of glenohumeral osteoarthritis. The medium-term outcome and survival of a cementless humeral head resurfacing was retrospectively evaluated in 23 patients affected with osteoarthritis or avascular necrosis after a 7.4 year follow-up. The global revision rate was 16%. A statistically significant improvement in the mean Constant score, visual analogue scale, and range of motion have been reported. No signs of loosening were registered, while in 12 cases a glenoid erosion was found. Humeral head resurfacing remains a reasonable option in patients with an intact rotator cuff for the treatment of osteoarthritis and avascular necrosis.

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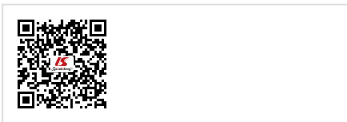
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INTRODUCTION

Glenohumeral osteoarthritis (OA) is a common cause of pain and physical limitation, with an estimated prevalence between 4% and 26%[1], affecting nearly a third of the world's population over 60 years of age[2]. The choice of treatment of shoulder OA is often controversial, and it is related to the surgeon and based on the patient's age, severity of symptoms, level of activity, radiographic findings, and medical comorbidities[3]. Activity modification, physical therapy, and anti-inflammatory drugs are the major nonoperative treatment options. In case of failure (nonresponding) of this therapeutic approach and when the patients may not wish to progress directly to surgery, intra-articular injection with either corticosteroid or hyaluronic acid or platelet-rich plasma[4] represents a valid alternative. Finally, surgery may be considered. As in other joints affected by severe OA, different surgical procedures are available, being joint arthroplasty the most effective treatment[3].

Shoulder arthroplasty was introduced by Neer *et al*[5]; from that date prosthesis design has evolved during time to better reproduce and accommodate the individual shoulder anatomy and variability[3,6]. During this evolution, implants have transitioned to shorter humeral stem lengths or even stemless components. The latter has been introduced in 2004 by Copeland, who designed a cementless humeral head resurfacing (HHR) prosthesis for the treatment of glenohumeral OA[7], providing good clinical results[8]. Over time, the indications to implant a cementless HHR changed and extended to other shoulder pathologies, such as humeral head avascular necrosis (AVN), instability arthropathy, rheumatoid arthritis, post-traumatic arthropathy, and cuff tear arthropathy, with good functional results[8,9]. The rationale to implant a cementless HHR is to restore the patient's individual humeral head anatomy, characterized by articular retroversion, neck shaft angle, lateral offset, and center of rotation, and it is easier to remove, preserving the bone stock for a possible



future revision[8,10].

The main criticism referred to HHR is usually related to the incorrect sizing and orientation of the prosthesis, resulting in an oversizing of the joint. A deviation of the center of rotation higher than 5 mm has been shown to correlate to clinical failure of the implant[10]. HHR failure rate is among 6% and 37%[9,11,12]. A direct correlation between overstuffing and glenoid wear has been demonstrated, leading to prosthesis failure[13]. Moreover, an operative change of the lateral glenohumeral offset as a predictive factor for implant failure has been reported[14]. Among other causes for prosthesis failure, rotator cuff tear, painful stiffness without glenoid erosion, or infections were reported[14].

The aim of the present study was to evaluate the medium-term outcomes and survival of a specific cementless HHR in a group of patients operated by a single surgeon in a single center.

MATERIALS AND METHODS

This is a report of prospectively collected data of 23 patients who have undergone cementless Aequalis HHR (Tornier, Warsaw, IN, United States) with a mean follow-up of 89 mo (range 44-131 mo).

All procedures involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with 1964 Helsinki Declaration and its later amendments. This study was reviewed and approved by the Ethics Committee/Scientific Council of the Istituto Chirurgico Ortopedico Traumatologico of Latina, Italy.

All participants gave informed written consent.

Subjects

Between February 2009 and May 2014, 25 shoulders in 23 patients (15 females and 8 males; mean age: 67.2 years, min/max: 39-83 years) were surgically treated with the same type of cementless HHR performed by the same surgeon (CC) in a single center. The indications for surface replacement were primary OA (15 shoulders) and humeral head AVN (10 shoulders). The exclusion criteria were the presence of rotator cuff tears (partial or complete) and a damaged glenoid (evaluated with magnetic resonance).

Surgical technique

All patients were operated under general anesthesia in the beach-chair position, by using the delto-pectoral approach. An L-shaped tenotomy of the subscapularis tendon was performed, followed by a capsular release for soft tissue balancing. The glenoid surface status was then assessed by retracting the humeral head. Once the humeral head was exposed, all osteophytes were carefully circumferentially removed. This step is critical because head sizing and head orientation are based off the anatomic neck. If the actual humeral head appeared to be in between sizes, the smaller size was selected. The humeral head was then reamed down to restore the original head height. The uncemented press-fit technique was the method of choice for fixing the resurfacing implant (Aequalis RH Tornier, Warsaw, IN, United States). Primary stability was achieved in all cases thanks to the presence of a tapered press-fit, tri-fin antirotational stem and a diamond-shaped macrotexture. In addition, all bone contacting surfaces were hydroxyapatite-coated.

In all cases, the long head biceps tenotomy was performed close to its glenoid attachment, followed by tenodesis in the bicipital groove. After implant reduction, the subscapularis was repaired in a tendon-to-tendon fashion using three to five nonabsorbable sutures. In no cases drains were placed in the shoulder.

The patient's arm was placed in a shoulder abduction pillow for 4 wk. Passive rehabilitation was started from day 2 with external rotation restricted to 0°. Patients were asked to support these movements actively. Free range of motion was allowed 6 wk after surgery.

Clinical study

Clinical evaluation included pre- and postoperative administration of the Constant scale and the visual analogue scale. The active range of motion was evaluated in pre- and postoperative time, with particular attention to the forward elevation, abduction, and external rotation with the arm at the side.

Radiological study

Pre- and postoperative radiographs were performed in two projections: A true antero-posterior view in neutral rotation and an axillary view. All radiographs were digitalized and scaled on the same size thanks to the software of Picture Archiving and Communication System monitor (General Electric, Chicago, IL, United States), available in the radiology department of our institute.

In the preoperative, the glenohumeral OA and humeral head AVN were radiologically classified according to Samilson and Prieto (mild: inferior humeral and/or glenoid exostosis < 3 mm in height; moderate: inferior humeral and/or glenoid exostosis measuring 3 mm to 7 mm, slight glenohumeral irregularity; severe: inferior humeral and/or glenoid exostosis measuring > 7 mm, glenohumeral joint narrowing and sclerosis) and Cruess (stage I: normal X-ray, changes on magnetic resonance; stage II: sclerosis, osteopenia; stage III: crescent sign indicating a subchondral fracture; stage IV: flattening and collapse; stage V: degenerative changes extend to glenoid).

Preoperative X-ray images revealed OA in 15 shoulders (2 cases of mild, 6 moderate, and 7 severe) and 10 shoulders affected by humeral head AVN (10 cases stage III).

During follow-up, the radiographic evaluation was useful to check signs of: (1) Loosening around the peg and in the eighth humeral zone. Probably loosening is intended as a radiolucent 2 mm wide line or greater around the implant without any change in position of the implant. Definite loosening was defined as a change in position of the implant over time; (2) Degenerative changes (*i.e.* glenoid erosion, humeral head or glenoidal osteophytes); and (3) Vertical humeral migration of the head intended as a superior migration of the prosthesis outside the center of the glenoid.

Statistical analysis

The paired t-test was used to determine whether there was a significant difference between preoperative and postoperative Constant score, visual analogue scale, and range of motion obtained at the latest check-up at 7.4 years. A *P* value of < 0.05 was considered to be statistically significant.

RESULTS

In total, 19 patients (21 shoulders) completed the follow-up.

Data on 4 shoulders in 4 patients were lost because of prosthesis failure due to a rotator cuff tear after a traumatic accident (1 case) (Figure 1) and glenoid erosion (3 cases) (Figure 2) that required a revision surgery (Table 1). In all the revised cases the implant was removed without complications, leaving a sufficient bone stock for reimplantation (Figure 3).

The Constant score improved from the preoperative mean value of 31.1 (range 16-57) to the postoperative mean value of 74.9 (range 57-100) (*P* < 0.001). In detail, an improvement of all the sections of the Constant score was registered from the preoperative to the postoperative latest evaluation and was statistically significant (*P* < 0.001) except for the recovery of the strength (*P* = 0.3).

The pretreatment visual analogue scale grading scale was 7.8 (range 5-10), while at the final follow-up decreased to 2.1 (range 0-5) (*P* < 0.001).

An improvement in the clinical evaluation of the active range of motion was also registered. The mean flexion forward changed from 75° (range 30°-120°) in the preoperative to 111° (range 60°-160°) in the postoperative (*P* = 0.06). The pre- and postoperative mean value of abduction were respectively 68° (range 30°-120°) and 104° (range 60°-160°) (*P* < 0.001), while the mean external rotation value pre- and postoperative were respectively 30° (range 10°-50°) and 54° (range 30°-75°) (*P* < 0.001) (Table 2).

No signs of loosening around the peg and in the eighth humeral zone[15] were detected at the latest follow-up. In 11 cases, a glenoidal erosion has been reported. In 3 patients, this condition was symptomatic, while in the remaining 8 it was not. In 12 cases the presence of inferior glenoidal osteophytes was registered, and in 7 cases humeral head osteophytes were registered. Only 1 case of superior humeral migration had been reported due to the traumatic rotator cuff tear (Figure 1).

The global revision rate was 16% at a mean follow-up of 7.4 years, and the survival rate was 84% (Figure 4).

Table 1 Demographic data of patients who required revision

Patient	Sex	Age	Indication	Lifespan of the prosthesis	Failure cause	Revision
1	Male	66	Right OA	65 mo (5.41 yr)	Glenoiditis	rTSA
2	Female	78	Right AVN	44 mo (3.66 yr)	Traumatic RCT	rTSA
3	Female	75	Right AVN	50 mo (4.16 yr)	Glenoiditis	rTSA
4	Male	48	Left AVN	66 mo (5.50 yr)	Glenoiditis	TSA

AVN: Avascular necrosis; OA: Osteoarthritis; RCT: Rotator cuff tear; rTSA: Reverse total shoulder arthroplasty.

Table 2 Preoperative and 7.4 yr postoperative clinical finding

	Preoperative value (min-max)	Postoperative value (min-max)	P value
Pain	3.20 (0-5)	12.38 (10-15)	< 0.001
Daily activity level	7.96 (6-11)	16.66 (12-20)	< 0.001
ROM	10.48 (2-17)	35.47 (28-40)	< 0.001
Strength	9.44 (3-25)	10.42 (4-25)	0.3
Constant score	31.08 (16-57)	74.95 (57-100)	< 0.001
VAS	2.88 (1-4)	7.76 (5-10)	< 0.001
Flexion forward	74.80° (30°-120°)	111.42° (60°-160°)	0.06
Abduction	68.00° (30°-120°)	104.28° (60°-160°)	< 0.001
External rotation	30.40° (10°-50°)	54.04° (30°-75°)	< 0.001

ROM: Range of motion; VAS: Visual analog scale.



Figure 1 Patient 2. X-ray of a right shoulder anteroposterior view. Note the superior humeral head migration caused by a traumatic rotator cuff tear 3, 6 yr after surgery.

DISCUSSION

Even if during the years the indications to implant a cementless HHR changed and extended from OA to numerous shoulder pathologies[8,9], the authors' rationale to implant a cementless HHR was to restore the patient's individual humeral head anatomy, and two major aspects were considered crucial: (1) The integrity of the rotator cuff; and (2) A good bone stock to fix the implant.

The latter aspect may be a problem in AVN. This condition in fact is characterized by the death of cellular components of bone secondary to an interruption of the subchondral blood supply determining a deep bone distortion with abnormal

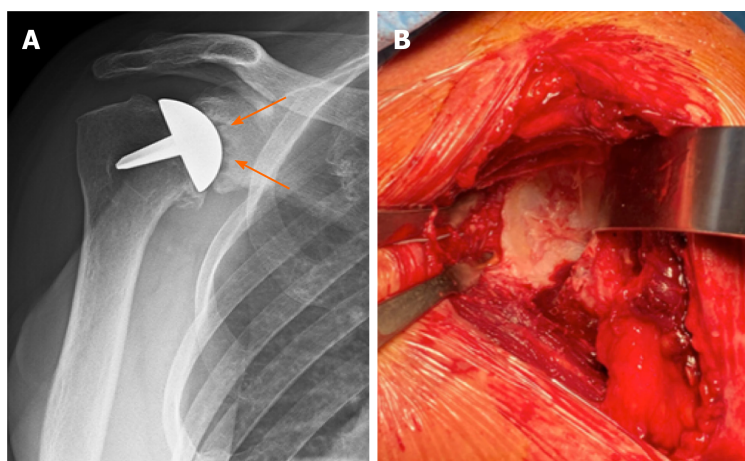


Figure 2 Patient 3. A: X-ray of the right shoulder. Anteroposterior view. An evident glenoid erosion (arrows) is detectable 5.5 yr after humeral head resurfacing; B: Revision surgery. Deltopectoral approach. After removal of the implant the glenoid surface damage was assessed by retracting the humerus.

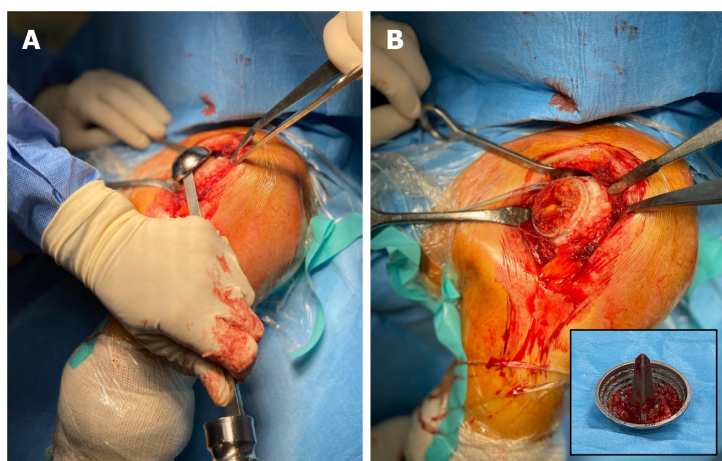


Figure 3 Patient 4. Revision surgery, deltopectoral approach. A: The removal of the implant; B: The humeral bone stock appears maintained after prosthesis removal (square).

architecture and for this reason may be considered not an absolute indication to implant a cementless HHR, especially in its late stages (IV and V according to Cruess).

According to the findings of the present study, the clinical and radiological results were good in a mean term follow-up of more than 7 years using the Aequalis HHR in the treatment of glenohumeral OA and humeral head AVN compared to similar data reported in the literature[9,11,14,16-19] (Figure 5).

In contrast, to our knowledge there exists only one paper reporting no failure at a long-term follow-up[20]. In that paper, the study population consisted of 14 young patients (aged 19-49 years) affected by juvenile idiopathic arthritis and treated with HHR with a 10.4 year follow-up period. The authors reported that only two shoulders required early arthroscopic subacromial decompression. This interesting study may have a limitation/bias in the age of its population because it was limited to young patients.

As underlined above, the use of HHR as the primary implant presents numerous advantages in all ages, but especially in younger patients. The cementless implant may preserve the bone stock, and this aspect could be useful during a future revision[7]. Moreover, HHR may be considered a valid alternative in the post-traumatic arthropathy to restore shoulder anatomy[7,14].

As already underlined in the literature and confirmed by this study, glenoid erosion is considered as the most important reported cause of prosthesis failure[14,16,17]. This complication could be caused by an incorrect assessment of the humeral head size and orientation, producing an overstuffing of the joint[10,21].

In the past, different attempts were suggested to limit glenoid erosion, and particular interest was given to the procedure employing a biological glenoid

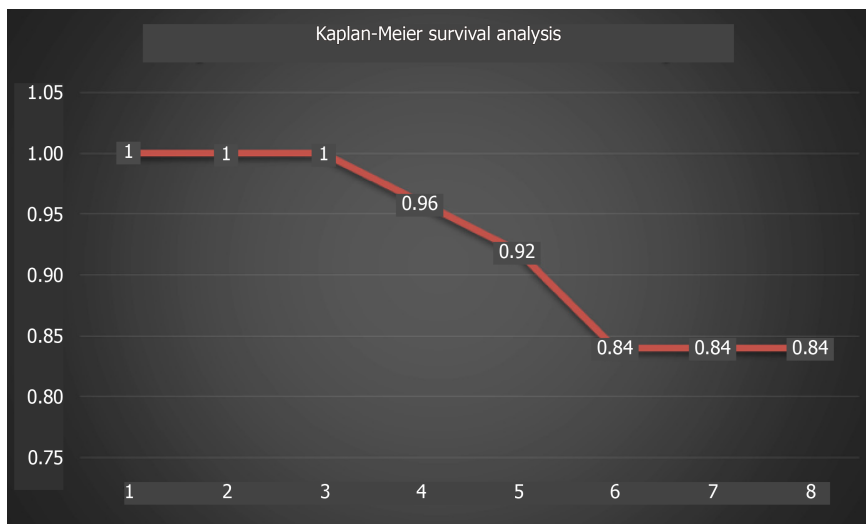


Figure 4 Kaplan-Meier survival analysis.

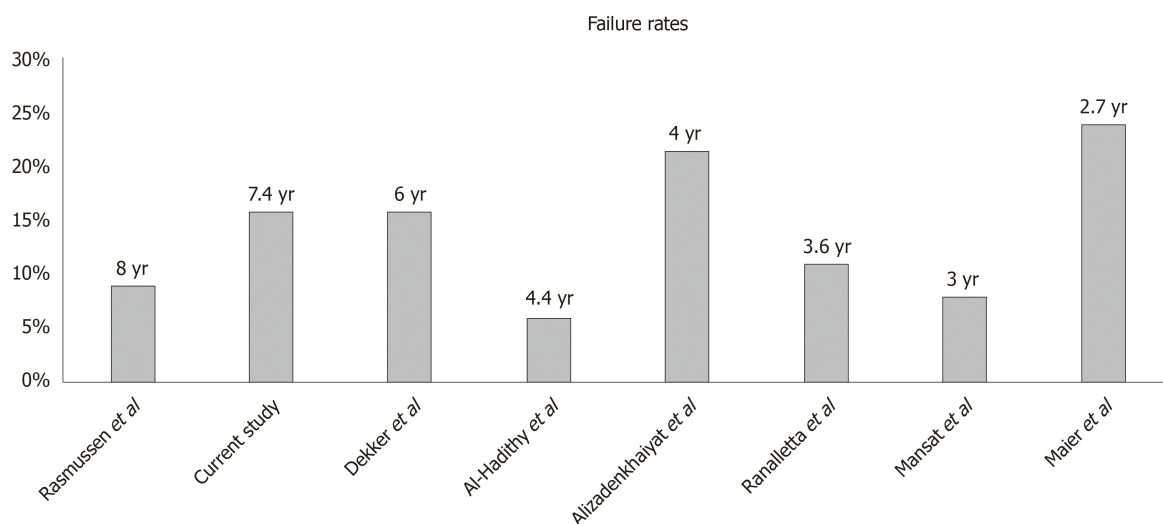


Figure 5 Reported incidence of humeral head resurfacing failure rates in the literature compared with the current study.

resurfacing[22-24]. After promising early results, all these attempts have failed. The reported long-term failure rate of the biological glenoid resurfacing was 56% using the anterior shoulder capsule even though the authors registered good clinical results after 5 years[22].

Also, the use of autograft Achilles tendon or allograft fascia lata for biological glenoid resurfacing was inconsistent. Elhassan *et al*[23] registered 10 cases of erosion in 13 patients (failure rate > 70%), so they do not recommend this kind of treatment. The same conclusion was drawn by Lollino *et al*[24] who proposed to resurface glenoid with the lateral meniscus. After a 2 year follow-up period, the authors reported a narrowing of the articular space, probably related to the meniscal reabsorption.

Taking into consideration the overall results of HHR, the weak part is to date the glenoid. This conclusion is apparently similar to the results of the traditional anatomical shoulder arthroplasty[25]. In fact, many studies have reported that the glenoid component loosening, and failure represented the most common long-term complication of total shoulder arthroplasty. This accounted for approximately 24% of all total shoulder arthroplasty complications[26], so that we have to conclude that the result of a shoulder replacement highly depends on the status of the glenoid, be it native or implanted. Unfortunately, this remains still true although glenoid component design, material, and surgical technique of implant including cement use have been rapidly changed and evolved during the last decades[25].

CONCLUSION

HHR can be considered a good treatment option in OA and humeral head AVN in patients with an intact rotator cuff. This paper, even though is based on a small cohort of patients, shows a good outcome with a failure rate of 16% in a 7.4 year follow-up. No loosening or infection issues were encountered. The main problem of this prosthesis is the higher revision rate due to glenoid erosion, which is comparable to reported rates on total shoulder arthroplasty. Its advantage is bone preservation in the proximal humerus.

ARTICLE HIGHLIGHTS

Research background

Glenohumeral osteoarthritis and avascular necrosis are causes of shoulder pain and disability. Shoulder arthroplasty is the most effective treatment. The implant design has evolved during time transitioning to shorter humeral stem lengths or even stemless components.

Research motivation

The rationale to implant a cementless humeral head resurfacing (HHR) is to restore the patient's individual humeral head anatomy, characterized by articular retroversion, neck shaft angle, lateral offset, and center of rotation, and it is easier to remove, preserving the bone stock for a possible future revision. The reported revision rate at a mid-term follow-up is not so high, so this could be an alternative to a total shoulder arthroplasty.

Research objectives

Our aim is to evaluate the medium-term outcome and survival of a cementless HHR in a group of patients affected with osteoarthritis or avascular necrosis.

Research methods

This is a report of prospectively collected data using HHR in 23 patients (15 female and 8 male) after a 7.4 year follow-up.

Research results

The global revision rate was 16%. Data on 4 shoulders in 4 patients were lost because of prosthesis failure. Nineteen patients (21 shoulders) completed the follow-up. No signs of loosening were registered, while in 12 cases a glenoid erosion was found. The osteophytes appeared 7 times on the humeral side and 12 on the glenoid. Superior humeral migration was recorded in only one case.

Research conclusions

The use of a cementless HHR in the treatment of osteoarthritis and early stage avascular necrosis could nowadays be consider a valid therapeutic option.

Research perspectives

Further research based on well-designed studies with longer follow-up examination and with a bigger patient population need to be performed in order to elucidate the efficacy of cementless HHR.

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