

Total hip arthroplasty in the treatment of osteonecrosis of the femoral head: then and now

Carlos J. Lavernia¹ · Jesus M. Villa^{1,2}

Published online: 19 June 2015

© Springer Science+Business Media New York 2015

Abstract The objective of this review is to summarize and analyze the survivorship and the reported results of the use of total hip arthroplasty (THA) in patients with osteonecrosis of the femoral head. In the past, THA was thought to have poor survivorship and poor clinical and radiological results in patients with this diagnosis. However, more recent reports have suggested an improvement in the survivorship, radiological results, and outcomes of THAs when performed for this condition. Surgeons have incorporated THA into their practice patterns to the point that an increasing percentage of patients with this particular diagnosis are currently being treated with it. When collapse and/or arthrosis of the necrotic femoral head are present, THA seems to be the most reliable and proven option for its treatment.

Keywords Total hip arthroplasty · Osteonecrosis · Femoral head · Outcomes

Introduction

Osteonecrosis (ON) of the femoral head commonly affects patients in the third, fourth, and fifth decades of life [1, 2].

This article is part of the Topical Collection on *Modern Surgical Treatment of Hip Avascular Necrosis*

✉ Carlos J. Lavernia
c@drlavernia.com

Jesus M. Villa
jesus@drlavernia.net

¹ The Center for Advanced Orthopedics at Larkin Hospital, 7000 SW 62nd Ave, Suite 600 South, Miami, FL 33143, USA

² Arthritis Surgery Research Foundation, 7000 SW 62nd Ave, Suite 601 South, Miami, FL 33143, USA

Symptomatic femoral head ON typically follows a progressive course. Total hip arthroplasty (THA) is indicated when the femoral head has collapsed and the joint shows advanced degenerative changes [3]. In the USA alone, approximately 20,000 to 30,000 new patients are diagnosed with ON annually, and 5 to 12 % of THAs are performed based on this diagnosis [2].

Early reports on THA showed poor survivorship and outcomes in patients with hip ON [4–8]. However, recent reports suggest an improvement in the survivorship or outcomes of THA when performed for this condition [9, 10, 11•, 12–21]. According to Mont et al. [22•] who performed a 16-year analysis of the Nationwide Inpatient Sample regarding the treatment of femoral head osteonecrosis in the USA, since 1993, reports have suggested an improvement in the survivorship of THA. By the year 1992, 75 % of the procedures performed to treat hip ON were THAs. By 2008, the incidence had increased to 88 %. During the same time period, the proportion of joint-preserving procedures decreased from 25 to 12 %. Moreover, the authors reported that the total number of procedures performed for this diagnosis has increased, which might reflect improved awareness of this disease and more aggressive diagnosis and treatment. Nonetheless, in the orthopaedic community and when performed for patients with ON of the femoral head, the perception remains that hip arthroplasties in this population may have poor outcomes. Therefore, the purpose of this review is to summarize and analyze the historical and most current clinical and radiological outcomes for those with hip ON treated with THA.

Material and methods

We performed a careful review of the literature using keywords “Total Hip Replacement” and “Necrosis” to query

The Journal of Bone & Joint Surgery, The Journal of Arthroplasty, Clinical Orthopaedics and Related Research, The Journal of the American Academy of Orthopaedic Surgeons, and Acta Orthopaedica. This was done for the last 10 years. In addition, the references of the selected reports were cross-referenced looking for additional sources, including historical series. In total, 23 studies were identified and analyzed, and all 23 are listed in the references at the end of this review. This article does not contain any studies with human or animal subjects performed by any of the authors.

Then

In the past, THA was believed to have reduced survivorship and worse outcomes in patients with ON of the femoral head when compared with its use in patients with other diagnoses. In 1981, Chandler et al. [8] evaluated 29 patients ($n=33$ hips) with a mean age of 23 years (range, 14 to 35 years) who underwent cemented THA. After a 5-year follow-up, 57 % showed evidence of actual or potential loosening of at least one component of the arthroplasty. The authors found that ON was among those factors that seemed to adversely affect the results. ON had been diagnosed in 11 of the 18 hips with problems; whereas of the remaining 15 hips, only three had ON. The reasons for this influence were not clear. Shortly thereafter, Stauffer et al. [7] analyzed 231 hips from the first 300 consecutive patients (1960 to 1970) who had a Charnley THA in the Mayo Clinic (Rochester, MN, USA). The authors placed particular attention to the roentgenographic loosening of the components and found that at 10 years, the incidence of loosening of the acetabular component was 11.3 % while the one of the femoral component was 29.9 %. When analysis was made according to preoperative diagnosis, 50 % of patients with diagnosis of ON (5 out of 10) had loosening of the femoral component. This particular rate of loosening was higher than the one of the overall series. Additionally, Dorr et al. [6], in a study of 108 total hip arthroplasties in 81 patients ranging in age from 14 to 45 years and with a mean follow-up of 4.5 years, found that the patients with worst prognosis for success following THA were less than 30 years of age, had osteonecrosis or osteoarthritis as the primary disease, and did not have an optimum reconstruction. This study is particularly interesting because it was not able to demonstrate significant differences between ON and osteoarthritis; nonetheless, it reported that ON was associated with poor results.

In 1990, Sarmiento et al. [5] analyzed the long-term radiographic outcomes in patients who were older than 50 years and in patients younger than 50 years of age. The performance of a total of 712 Charnley and STH prostheses (performed between 1970 and 1980) was evaluated as a function of the age and of the underlying disease (osteoarthritis, rheumatoid arthritis, or ON). Following a mean follow-up of 7 years, 19 %

of younger patients had ON and 32 % had rheumatoid arthritis. In contrast, 11 % of older patients had ON and 12 % had rheumatoid arthritis. Even though the rates of acetabular radiolucency and wear were higher in the younger patients, when the patients were grouped according to the underlying disease, these higher rates were found only in the younger patients who had rheumatoid arthritis or ON. In other words, only in patient who had osteoarthritis, there were no significant differences between older and younger patients. The authors attributed the differences observed to the disease and considered that a principal factor of this particular finding was the quality of trabecular bone available for fixation of the acetabular component. In 1999, Ortiguera et al. [4] compared the outcomes of Charnley THAs performed for ON and those done for osteoarthritis. The patients were matched for age, sex, surgical approach, prosthesis, and surgeon (matched-pair analysis of 188 hips performed at the Mayo Clinic in Rochester, MN, USA). After a mean follow-up of approximately 18 years (range 10 to 25.4 years), the authors found that in patients younger than 50 years, the revision rate in ON (50 %) was significantly higher than the one in any other group. Similarly, the mechanical failure rate (defined as revision for loosening plus radiographic loosening) in ON was significantly greater in patients younger than 50 years. Additionally, they found that radiographic femoral loosening was greater in ON at all follow-up intervals and dislocations occurred more frequently in the ON group than in the osteoarthritis group. Furthermore, the results in both groups were similar in patients older than 50 years of age; however, patients with osteonecrosis had an increased rate of dislocation. After these findings, the authors concluded that cemented THA should be recommended only with caution in patients with osteonecrosis who are younger than 50 years of age.

Now

Multiple reports have suggested marked improvement in the survivorship, radiological results, and clinical outcomes of contemporary THAs when performed for ON of the femoral head. Stavrakis et al. [23•] performed a comparison of the incidence of complications after THA in patients with or without osteonecrosis. They studied all patients undergoing THA from 1995 to 2010 in the state of California and found that the total proportion of comorbidities for the group without necrosis was 39.24 versus 50.76 % for the ON group. Not surprisingly, patients with ON had increased rates of readmission and sepsis. However, ON was not associated with an overall increase in revision surgery. Furthermore, ON was found protective against revision surgery even though these patients were younger than osteoarthritis patients. It was not clear why, but the authors hypothesized that many patients with ON have multiple comorbidities and chronic diseases which

may limit their activity level and consequently increase the longevity of their prosthesis. We think that this could have been exactly the same reasons by which ON patients had more readmissions and sepsis. Kim et al. [10] reported the outcomes of cementless modular THA in patients younger than 50 years with femoral head ON. At a minimum follow-up of 15 years, the mean Harris hip score (HHS) improved from 36 points at baseline to 92.7 points at final follow-up while 95.3 % of hips demonstrated stable bone ingrowth. There were no hips with loosening or requiring revision for aseptic loosening. With stem revision as the end point, survivorship for any reason was 93.8 %; for aseptic loosening, it was 100 % at 16.8 years. Han et al. [16] evaluated the clinical and radiological results as well as the survivorship of a cementless wedge-shaped tapered prosthesis in young patients with ON. The authors found that the mean HHS was 92 points at the latest follow-up. Endosteal bone formation was observed in 98.9 % of the hips ($n=94$). With revision for stem loosening as the end point, the survival rate was 98.9 % at 12.7 years. Bedard et al. [11•] evaluated the minimum 10-year results of 80 cementless THAs in patients ($n=66$) with ON. Outcomes of interest included need for revision, radiographic results, and clinical outcomes such as the HHS. The results were compared to the author's previously reported series of 48 cemented THAs performed for ON with a similar follow-up interval. At final follow-up, 12.5 % of hips underwent reoperation. There were no revisions for infection, and only one prosthesis was revised for aseptic loosening. None of the prostheses had radiographic evidence of loosening of the acetabular component, and only one implant had radiographic evidence of femoral component loosening. The mean HHS was 80.3 points at the latest follow-up. Loosening and revision for loosening were significantly lower in the cementless contemporary group when compared to the author's cemented historical series. Min et al. [15], in a minimum 5-year follow-up study, reported the survivorship as well as the radiographic and clinical outcomes of 162 hips with ON of the femoral head that had cementless THAs using highly cross-linked polyethylene liner. The authors found that there were no component revisions at the latest follow-up. The all-cause survival rate with the endpoint of component revision was 100 % at 10 years after surgery. Furthermore, none of the femoral or acetabular components displayed radiographic evidence of mechanical loosening or osteolysis. The mean rate of linear liner wear was 0.038 mm/year. The mean preoperative HHS improved from 48.8 points preoperatively to 93.4 points at the final follow-up. Only 3.9 % of patients had slight thigh pain that did not limit activity. None of the patients required any type of walking support at the latest follow-up. Kim et al. [13] evaluated the midterm results (minimum follow-up was 10 years) of a cementless ceramic-on-ceramic THA (127 hips) in patients younger than 30 years of age. In this series, ON represented 54.3 % of all diagnosis. The authors paid particular attention to the prevalence of thigh pain,

bone resorption due to stress-shielding in the proximal femur, aseptic loosening, and osteolysis in addition to the clinical outcomes. The authors found that after a 1-year follow-up, none of the patient reported having thigh pain. At the latest follow-up, all femoral stems and all but one acetabular component were well fixed. There were no reports of hip squeaking, ceramic fracture, loosening, or osteolysis. The mean HHS was 95 points, and the University of California Los Angeles (UCLA) activity score was 8 points. In this series, there was a high survival rate (without evidence of osteolysis) even though more than half of the patients were younger than 30 years of age and had a diagnosis of ON. Baek et al. [14] reported the clinical outcomes after cementless THA with ceramic bearings in patients younger than 50 years with ON of the femoral head performed by a single surgeon in a single institution. After a mean follow-up of 7.1 years (range, 6 to 9 years), the mean (HHS) was 97.0 points. There was no loosening or osteolysis observed in any hip, and no arthroplasty had been dislocated or revised. However, in this particular ceramic-on-ceramic series, 13 patients (14 hips, 20 %) reported noise in the hip. Nonetheless, the results were encouraging in these arthroplasties performed in young active patients with ON of the femoral head.

Cemented versus cementless systems

Kim et al. [9] also reported the results of contemporary THA with and without cement in patients with ON at a mean follow-up of 17 years. In this series, 50 patients (100 hips) had simultaneous bilateral arthroplasties with a cemented stem in one hip and a cementless stem in the contralateral hip. Forty-eight patients (48 hips) had unilateral THA with a cementless stem. All patients had cementless acetabular components. The authors found that there was no difference in the HHS or WOMAC scores between hybrid and fully cementless prosthesis. At the latest follow-up, 83 % of 48 acetabular components in the hybrid group and 85 % of 94 acetabular components in the fully cementless group were intact; 98 % of the femoral components in both groups were also intact. Wear and periacetabular osteolysis were the causes of failure in the hips that required revision. In young patients with ON, contemporary cementless cups and cemented or cementless stems provided durable long-term fixation and substantial pain relief in the long term.

Osteonecrosis versus osteoarthritis

Seyler et al. [21] evaluated the safety and efficacy of the ceramic-on-ceramic bearing in patients with ON. In this prospective randomized multicenter clinical study, 70 patients with ON of the femoral head (79 hips) received a cementless ceramic-on-ceramic bearing system and were directly matched (for gender, preoperative HHS, and age at surgery)

to 76 patients with osteoarthritis of the hip (79 hips) who were managed with the same implant. Both groups were compared with 25 patients (26 hips) with ON and 25 patients (26 hips) with osteoarthritis who were managed with a cementless cobalt-chromium-on-polyethylene bearing system. The authors found that at latest follow-up, the HHS for ceramic-on-ceramic bearings were similar for both ON and osteoarthritic hips (96 versus 96 points) as well as the cobalt-chromium-on-polyethylene bearing group (96 versus 97 points). The 7-year survival probability was 95.5 % for the ON hips and 89.4 % for the osteoarthritic hips in the ceramic-on-ceramic bearing group and 92.3 % for the ON hips and 92.9 % for the osteoarthritic hips in the cobalt-chromium-on-polyethylene bearing group. Mont et al. [20] evaluated the clinical and radiographic results of uncemented THA in young adults with ON of the femoral head (mean age, 38 years; 52 hips) and compared them to the ones seen in young adults with osteoarthritis (mean age, 42 years; 52 hips). The clinical outcome was categorized as excellent or good (HHS \geq 80 points, no use of walking aid, non-painful hip), fair (score 70–79 points, occasional use of walking aid and/or mild hip pain), or poor (latter category not satisfied). The mean follow-up was 37 months (range, 24 to 50 months). The authors found that the outcome was good to excellent for 94 % of the hips in the ON group and for 96 % of the hips in the osteoarthritis group. The survival rate (free of revision) at the latest follow-up was 96.1 % for the ON group, and it was 98 % for the osteoarthritis group. Schneider and Knahr [18] retrospectively analyzed the clinical and radiographical outcomes of 129 cementless THAs in younger patients with either ON or primary/secondary osteoarthritis. The radiographic analysis did not show significant differences in regard to radiolucent lines at the bone-prosthesis interface, osseointegration, and heterotopic ossification in patients with ON and those with other diagnoses. There was no higher risk of loosening in patients with ON. Thus, the authors concluded that they could not confirm ON as a risk factor in THA.

Osteonecrosis and systemic lupus erythematosus

Woo et al. [17] compared the clinical outcomes, radiologic results, and complications associated with THA between a cohort of patients with ON and systemic lupus erythematosus and a group of patients with ON but without lupus. The authors found that there were no significant differences. Furthermore, after a mean follow-up of 97.8 months, the 13 lupus patients (19 hips) in this study had excellent results after THA. These patients had dramatic improvements in HHS without significant complications.

Osteonecrosis and sickle cell disease

Issa et al. [12] compared the survivorship and clinical and radiological outcomes of cementless primary THAs in sickle

cell ON patients (42 hips; mean follow-up, 7.5 years) with the ones of a cohort of ON patients (102 hips; mean follow-up, 7 years) who did not have this disease. In the sickle cell cohort, survivorship was 95 %, and it was 97 % in the ON group without sickle cell disease. The mean postoperative HHS were 87 and 88 points, respectively. They found no differences in radiographic survivorship (95 versus 97 %; $p=0.6$) or HHS (87 versus 88 points; $p=0.75$) between the cohorts. Hernigou et al. [19] retrospectively reviewed 312 cemented (both, cup and stem) arthroplasties performed in patients with ON and sickle cell disease. Following a mean follow-up of 13 years (range, 5 to 25 years), even though medical complications were observed after 85 operations (27 %), the proportion of orthopaedic complications was 13 %. With revision for aseptic loosening as the end point, the survival rate of both original components at 10 and 15 years was 91 and 86 %, respectively. Even though the authors did not find THA to be completely safe in this particular high-risk population, the risk-to-benefit ratio was found reasonable.

Conclusions

The early reports of outcome in total hip arthroplasty in patients with ON were poor; however, recent reports have demonstrated marked improvement in the survivorship and outcomes of contemporary cemented and cementless total hip arthroplasties when performed for ON of the femoral head. Surgeons have incorporated THA into their practice patterns to the point that an increasing percentage of patients with this particular diagnosis have surgery. Currently, when full collapse and/or secondary arthrosis of the necrotic femoral head are present, THA seems to be the most long-lasting, reliable, successful, and proven option for its treatment. The outcome of this surgery in ON is dependent on the causality of the disease.

Compliance with Ethics Guidelines

Conflict of Interest Jesus M. Villa declares no conflict of interest. Carlos J. Lavernia reports personal fees from Stryker, personal fees from Wright Medical Technology, Inc., grants and personal fees from MAKO Surgical, personal fees from Johnson and Johnson, personal fees from Symmetry Medical, personal fees from Zimmer, outside the submitted work. Dr. Lavernia is a board member of the American Association of Hip and Knee Surgeons and the Florida Orthopaedic Society and is an editorial board member of the Journal of Arthroplasty.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by any of the authors.

References

Papers of particular interest, published recently, have been highlighted as:

- Of importance

1. Lavernia CJ, Sierra RJ, Grieco FR. Osteonecrosis of the femoral head. *J Am Acad Orthop Surg.* 1999;7(4):250–61.
2. Zalavras CG, Lieberman JR. Osteonecrosis of the femoral head: evaluation and treatment. *J Am Acad Orthop Surg.* 2014;22(7):455–64.
3. Mont MA, Jones LC, Hungerford DS. Nontraumatic osteonecrosis of the femoral head: ten years later. *J Bone Joint Surg Am.* 2006;88(5):1117–32.
4. Ortiguera CJ, Pulliam IT, Cabanela ME. Total hip arthroplasty for osteonecrosis: matched-pair analysis of 188 hips with long-term follow-up. *J Arthroplasty.* 1999;14(1):21–8.
5. Sarmiento A et al. Total hip arthroplasty with cement. A long-term radiographic analysis in patients who are older than fifty and younger than fifty years. *J Bone Joint Surg Am.* 1990;72(10):1470–6.
6. Dorr LD, Takei GK, Conaty JP. Total hip arthroplasties in patients less than forty-five years old. *J Bone Joint Surg Am.* 1983;65(4):474–9.
7. Stauffer RN. Ten-year follow-up study of total hip replacement. *J Bone Joint Surg Am.* 1982;64(7):983–90.
8. Chandler HP et al. Total hip replacement in patients younger than thirty years old. A five-year follow-up study. *J Bone Joint Surg Am.* 1981;63(9):1426–34.
9. Kim YH et al. Contemporary total hip arthroplasty with and without cement in patients with osteonecrosis of the femoral head: a concise follow-up, at an average of seventeen years, of a previous report. *J Bone Joint Surg Am.* 2011;93(19):1806–10.
10. Kim SM et al. Cementless modular total hip arthroplasty in patients younger than fifty with femoral head osteonecrosis: minimum fifteen-year follow-up. *J Arthroplasty.* 2013;28(3):504–9.
11. • Bedard NA et al. Cementless THA for the treatment of osteonecrosis at 10-year follow-up: have we improved compared to cemented THA? *J Arthroplasty.* 2013;28(7):1192–9. **Shows the improvements in revision rates and outcomes of contemporary cementless THAs when compared to the author's previously reported series of cemented THAs performed for ON.**
12. Issa K et al. Excellent results and minimal complications of total hip arthroplasty in sickle cell hemoglobinopathy at mid-term follow-up using cementless prosthetic components. *J Arthroplasty.* 2013;28(9):1693–8.
13. Kim YH, Park JW, Kim JS. Cementless metaphyseal fitting anatomic total hip arthroplasty with a ceramic-on-ceramic bearing in patients thirty years of age or younger. *J Bone Joint Surg Am.* 2012;94(17):1570–5.
14. Baek SH, Kim SY. Cementless total hip arthroplasty with alumina bearings in patients younger than fifty with femoral head osteonecrosis. *J Bone Joint Surg Am.* 2008;90(6):1314–20.
15. Min BW et al. Highly cross-linked polyethylene in total hip arthroplasty for osteonecrosis of the femoral head: a minimum 5-year follow-up study. *J Arthroplasty.* 2013;28(3):526–30.
16. Han SI et al. Long-term durability of the CLS femoral prosthesis in patients with osteonecrosis of the femoral head. *J Arthroplasty.* 2013;28(5):828–31.
17. Woo MS, Kang JS, Moon KH. Outcome of total hip arthroplasty for avascular necrosis of the femoral head in systemic lupus erythematosus. *J Arthroplasty.* 2014;29(12):2267–70.
18. Schneider W, Knahr K. Total hip replacement in younger patients: survival rate after avascular necrosis of the femoral head. *Acta Orthop Scand.* 2004;75(2):142–6.
19. Hernigou P et al. Total THA in adult osteonecrosis related to sickle cell disease. *Clin Orthop Relat Res.* 2008;466(2):300–8.
20. Mont MA et al. Uncemented total hip arthroplasty in young adults with osteonecrosis of the femoral head: a comparative study. *J Bone Joint Surg Am.* 2006;88 Suppl 3:104–9.
21. Seyler TM et al. Use of an alumina-on-alumina bearing system in total hip arthroplasty for osteonecrosis of the hip. *J Bone Joint Surg Am.* 2006;88 Suppl 3:116–25.
22. • Johnson AJ et al. Treatment of femoral head osteonecrosis in the United States: 16-year analysis of the nationwide inpatient sample. *Clin Orthop Relat Res.* 2014;472(2):617–23. **Shows an increase in the utilization of THA for the treatment of femoral head osteonecrosis.**
23. • Stavrakis AI, SooHoo NF, Lieberman JR. A comparison of the incidence of complications following total hip arthroplasty in patients with or without osteonecrosis. *J Arthroplasty.* 2015;30(1):114–7. **Shows that currently, ON is not associated with an overall increase in revision surgery.**