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A current review of core decompression in the treatment of osteonecrosis of the femoral head

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Abstract The review describes the following: (1) how traditional core decompression is performed, (2) adjunctive treatments, (3) multiple percutaneous drilling technique, and (4) the overall outcomes of these procedures. Core decompression has optimal outcomes when used in the earliest, precollapse disease stages. More recent studies have reported excellent outcomes with percutaneous drilling. Furthermore, adjunct treatment methods combining core decompression with growth factors, bone morphogenic proteins, stem cells, and bone grafting have demonstrated positive results; however, larger randomized trial is needed to evaluate their overall efficacy.

Keywords Osteonecrosis of the femoral head · Core decompression · Patient-reported outcomes · Percutaneous drilling

Introduction

In the treatment of osteonecrosis of the femoral head (ONFH), core decompression is used in the earliest precollapse stages of disease in an attempt to delay and/or prevent the need for total hip arthroplasty (THA). The most ideal lesion treated with this procedure is a precollapse and small (<15 % of femoral head or Kerboul angle <200°) [1–4]. These procedures are typically performed by the drilling and removal of an 8- to 10-mm cylindrical core from the osteonecrotic lesion [5]. In addition, another commonly used technique involves multiple percutaneous drillings [5, 6]. Techniques have been combined with several other adjunctive treatment modalities such as bone grafting and the addition of growth and differentiation factors [7–12]. The purpose of this review is to describe the following: (1) how traditional core decompression is performed, (2) adjunctive treatments, (3) multiple percutaneous drilling, and (4) the overall outcomes of this procedures.

Technique of standard core decompression

The patient is placed under general anesthesia and is then prepared and draped in an aseptic manner. Under fluoroscopic guidance, a Kirschner wire is drilled with an entry point laterally, but superior to the lesser trochanter medially. Once it is determined that the guide wire is in the appropriate place, an 8- to 10-mm-wide trephine is inserted into the lesion with care not to penetrate the femoral head nor to violate the articular cartilage. A core of bone is removed from the lesion, the skin is closed with one suture, and a sterile dressing is applied [5]. Following surgery, patients are discharged home the same day and are allowed 50 % weightbearing on the affected leg, for 6 weeks. After 6 weeks, patients can progress to full weight-bearing. Patients are then given abductor strengthening exercises and educated to avoid high impact activities for 1 year [5]. Patients are followed up with plain radiographs and clinical evaluation at 6, 12 weeks, 6, 12 months, and annually thereafter.

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Overall outcomes of traditional core decompression

When evaluating outcomes of this procedure, it is important to distinguish the results of older versus more recent studies. In a systematic literature review, Marker et al. [12] evaluated the clinical and radiographic outcomes of core decompression in surgeries done before [13–22] and after 1992 [1, 2, 10, 23–31] (n=1268 and 1337 hips, respectively). The authors demonstrated that in procedures performed before 1992, 41 % of hips required additional surgery after a mean follow-up of 65 months (range, 3 to 216 months). However, in surgeries conducted after 1992, only 30 % of hips required another operation after a mean follow-up of 63 months (range, 1 to 176 months). Given this improvement in the overall efficacy of core decompression, the authors concluded that core decompression is a viable option for treating the early stages of ON. This may be due to improvements in surgical indications or technique as well as improvement in postoperative care.

Similarly, Rajagopal et al. [32•] assessed the efficacy of core decompression in a systematic literature review of four level IV studies (n=139 hips) [13, 27, 33, 34]. After a minimum 2-year follow-up, approximately 26 % of all cases were converted to THA. Furthermore, they found that those in Ficat stage I disease and lesions occupying <50 % of the femoral head were more likely to achieve satisfactory outcomes (no additional surgery and Harris Hip Scores >70 points). The authors further support the notion that core decompression is best when performed in the earliest stages of the disease.

Although there is a paucity of studies within the last 10 years assessing long-term (>10 years) outcomes, there are some older studies evaluating long-term results following decompression. Fairbank et al. [35] evaluated patients in precollapse and postcollapse disease (n=128 hips). After a 10-year follow-up, the hip survival rates those in Ficat stages I, II, and III of disease were 96, 74, and 35 %, respectively. Therefore, long-term studies confirm that those with the best outcomes following this procedure are those with early precollapse disease.

In summary, more recent studies have conferred better results than older studies with core decompression. This may be due to improved patient selection or evolving surgical technique. As more long-term outcome studies are published, core decompression will likely gain traction as a treatment of early stage ONFH.

Most studies have reported excellent outcomes for this procedure when performed in early precollapse disease stages. Yoon et al. [1] evaluated the role of disease stage and lesion location on the outcomes (n=39 hips). After a mean follow-up of 61 months, they found that patients who had Ficat stage II or III disease (n=17 out of 22 hips) were significantly more likely to require THA than those with stage I disease (n=5 out of 17 hips) (p<0.001). In addition, when the lesions were located laterally or centrally, there was a significantly increased rate of conversion to a THA than those with medial lesions (p=0.009). They also noted that larger sized lesions (>30 % of femoral head) had a significantly greater chance of clinical failure (p<0.001). They concluded that the ideal candidate has precollapse disease with lesions less than 15 % of the size of the femoral head.

These conclusions are supported by Iorio et al. [2], who demonstrated that patients who had Ficat stage I disease had markedly higher 5-year survivorship than those with stage IIA and IIB disease (75 % versus 30 % versus 17 %, respectively). Therefore, the authors concluded that excellent survivorship occurs for those with stage I disease, but stage II disease patients may require alternative treatments.

Additionally, lesion size affects the efficacy of core decompression. Mazieres et al. [3] evaluated 20 hips with Ficat stage II disease. After a mean 24-month follow-up, 50 % of the hips (10 hips) showed signs of radiographic progression. When stratifying the cohort by lesion size (>23 and ≤23 % of the femoral head, respectively), those with smaller lesions (n=8 hips) only had 1 hip with disease progression, while 9 of 12 hips with larger lesions showed radiographic progression. The authors concluded that all decisions regarding this procedure should take into account whether the femoral head has collapsed as well as the volume of the lesions.

The use of core compression after the femoral head has collapsed has resulted in less than optimal outcomes. After a mean follow-up of 12 years (range, 4 to 18 years), Mont et al. [4] evaluated a cohort with postcollapse ONFH (n=68 hips). Only 29 % of the hips (n=20) had satisfactory outcomes (no additional surgeries and HHS ≥75 points). Furthermore, when categorized by disease stage, 41 % of the Steinberg stage III hips (n=18 out of 44 hips) required a THA, and 92 % of the stage IV hips (n=22 out of 24 hips) underwent a THA. Therefore, diagnosis before femoral head collapse is crucial for core decompression to be effective.

There have been attempts to use various adjunctive therapies with this procedure such as the following: (1) bone grafting [13, 23, 26]; (2) addition of mesenchymal cells [13, 23, 26]; and (3) tantalum rod insertion [9, 11, 36–41].

Bone grafting

Different types of bone grafts have been introduced into core tracts with the goal of providing structured support and further optimizing patient-reported outcomes. It is believed that bone grafting can stimulate repair and act as the foundation on which new bone may form. Wei and Ge [42] assessed the outcomes of a large cohort of patients in ARCO stage II and III ON following core decompression and concurrent nonvascularized bone grafting (n=223 hips). After a mean follow-up of 24 months (range, 7 to 42 months), they found a hip survival rate (no further surgeries required) of 81 % and a mean Harris Hip Score (HHS) that increased from 61 to 86 points at latest follow-up. Furthermore, multiple studies have shown that this can be an effective method for delaying the need for THA while subsequently allowing core decompression to be effective in later stages of ON [42–46].

Mesenchymal stem cells

There have been attempts to use core decompression with the addition of bone marrow cells (BMC) [8, 10, 47–49, 50•]. Li et al. [8] compared the use of BMC therapy to core decompression alone in a meta-analysis of 4 studies (n=219 hips) [47–49, 50•]. After a follow-up of 18 months, the authors demonstrated that significantly less patients in the BMC cohort required additional surgeries and/or procedures than those in the core decompression cohort (OR=0.11; p<0.01). Therefore, the authors concluded that the implantation of BMC may result in better outcomes than the use of core decompression alone. Therefore, BMC implantation may hold future promise as an adjunctive therapy.

Tantalum rod

Core decompression with the insertion of a porous tantalum rod initially showed some positive results [7, 37, 40]. However, many of these studies were done on very small cohorts, and the removal of these implants has led to complications such as fracture [7, 37, 40, 51–55]. Therefore, we do not recommend this as an adjunctive procedure. Recently, Ye et al. evaluated the efficacy of this adjunct (n=12 hips). After a mean follow-up of approximately 37 months (range, 6 to 47), 5 hips (42 %) required THA and 1 hip had a hardware failure.

Description of multiple percutaneous drilling decompression

Despite the excellent results with traditional core decompression, there are complications that can occur such as violation of the articular cartilage or subtrochanteric fractures. In an attempt to minimize these complications, instead of drilling one large tract, some have used multiple percutaneous drilling. Using a small diameter pin, multiple passes were made into the lesion [5, 56]. Recently, it has been used by number of surgeons with excellent results [5, 56–58].

For this technique, the patient is placed in the supine position on a fracture table, placed under intravenous sedation, and prepared and draped in an aseptic manner. The extremity is placed in slight internal rotation, the Steinman pin or drill is then inserted laterally above the level of the lesser trochanter, and it is advanced under fluoroscopic guidance toward the lesion [5]. Although dependent on surgeon preference, larger sized lesions require more passes (minimum, 2 to 3 passes) than smaller ones (1 pass) [56, 57]. After its completion, the pins are removed, direct pressure is held at the site, and a sterile dressing is applied. Postoperative care is similar to that following traditional decompression with the patient being 50 % weightbearing for 6 weeks. After 6 weeks, the patient is allowed to bear full weight and is given hip and abductor strengthening exercises to complete. The patient is also educated to avoid high impact activities for at least 1 year and is instructed to follow up at 6, 12 weeks, 6, 12 months, and annually thereafter.

Outcomes of percutaneous drilling

Outcomes associated with this percutaneous drilling technique are comparable to standard core decompression. In 2004, Mont et al. [57] were one of the first to report on this technique using multiple 3.2-mm drillings (2 to 3 holes) to achieve decompression in a cohort of patients who had precollapse ONFH (n=45 hips). Failure was defined as an HHS less than 70 and/or requiring additional surgery. After a mean follow-up of 24 months (range, 20 to 39 months), among patients with Ficat stage I disease (n=30 hips), 80 % (24 hips) had successful outcomes by the time of their last follow-up. Similarly, Song et al. [56] evaluated this technique in patients who had both precollapse and postcollapse disease (n=163 hips). They used 3.6-mm Steinmann pins and a mean of 12 holes (range, 4 to 22 holes). At 87-month mean follow-up (range, 60 to 134 months), 66 % of the hips (108 hips) were considered to have successful outcomes (HHS ≥75 points and no additional surgery). Of the patients with Ficat stage I disease, 79 % demonstrated clinically successful outcomes (n=31 of 39 hips), while 77 % of patients with stage II ON were deemed clinically successful (n=62 of 81 hips). Furthermore, the authors found that there was a significantly higher survivorship in patients with Ficat stage I or II than in patients with stage III ON (p<0.01). Moreover, there was a significantly higher survivorship in patients with small (<25 % involvement, n=15 of 15 hips) or medium lesions (25 to 50 % involvement, n=37 of 44 hips) compared with large lesions (>50 % involvement, 56 of 204 hips, p<0.01).

Recently, Omran [59••] assessed and compared the use of the multiple drilling technique (n=33 hips) to the conventional technique (n=61 hips) in a cohort of patients with sickle cell disease in Ficat stage I or II ONFH (n=94 patients). After a minimum follow-up of 2 years, patients had significant reductions in pain and improvement in HHS regardless of the technique. The authors concluded that although the multiple drilling technique is less invasive, it has similar outcomes compared to conventional decompression.

In summary, the use of multiple drilling technique of femoral head decompression has demonstrated excellent survivorship and outcomes. When compared to traditional methods, this newer approach has demonstrated similar results and may be easier to perform with fewer complications.

Conclusion

The efficacy of core decompression for the treatment of ONFH remains an area of controversy. However, most of the studies indicate that this management strategy is associated with the best outcomes when used in the earliest, precollapse stages of the disease with small lesions. Efficacy has improved over the past 20 years, and this may be due to improved patient selection or the use of new surgical techniques such as multiple percutaneous drilling. As this treatment modality continues to evolve, further studies should focus on new surgical techniques and adjunctive therapies that may further the prevention and/or delay of THA.

Compliance with ethics guidelines

Conflict of interest Todd P. Pierce, Julio J. Jauregui, and Randa K. Elmallah declare that they have 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. He is also a board member of the American Association of Hip and Knee Surgeons, the Florida Orthopaedic Society, and the Journal of Arthroplasty.

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- •• Of major importance

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