The purpose of this study was to evaluate the intraosseous use of a flexible endoscope during core decompression in identifying avascular bone in the femoral head that did not meet magnetic resonance imaging diagnostic criteria for osteonecrosis. The flexible endoscope was used to visually examine and locate avascular bone in the entire core track. A high-speed burr was then used to debride the avascular bone. This debridement process was continued until a host bed of porous bleeding cancellous bone was observed, comprising thorough debridement of the femoral head. Autologous cancellous bone graft was then packed into the residual cavity and stabilized. Ten patients (13 hips total) with an average age of 49 years (range, 34-58 years) were included in the study. Eight patients were fully ambulatory at 3 weeks (range, 1-3 weeks). For all 13 hips, the mean preoperative Harris Hip Score was 43 (range, 30-75) and improved to a mean of 93 (range, 60-100) postoperatively. Eighty-five percent of patients (11 of 13 hips) demonstrated a good to excellent outcome at a minimum 2-year follow-up (range, 27-45 months). Flexible intraosseous endoscopy helped identify avascular bone that did not appear on the preoperative magnetic resonance imaging, safely widen the surgical margins of the core decompression track, and achieve thorough debridement of the femoral head using a minimally invasive technique.
Osteonecrosis, also known as avascular necrosis, of the femoral head is a devastating disease that commonly affects individuals in the third to fifth decades of life. Chronic pain and loss of hip joint range of motion characterize this disease and substantially limit the productivity of these individuals. Although the ultimate goal of treatment is preservation of the joint and pain relief, many patients present with advanced disease and, consequently, the least invasive joint preservation procedure (ie, core decompression) is less likely to succeed. Several authors have created stages for osteonecrosis of the femoral head and have correlated the outcome with the extent of involvement. However, successful outcomes following core decompression alone vary substantially, making the consideration or adoption of joint preservation procedures used for early-stage osteonecrosis with the rendering of a consensus unlikely. Therefore, the current author hypothesized that new information about osteonecrosis could improve understanding of this disease and that such information could be obtained by inserting a flexible endoscope into the femoral head.

Therefore, in view of the well-accepted hypothesis of disrupted blood flow as the etiology for osteonecrosis and magnetic resonance imaging (MRI) in quantifying the extent of involvement, an adjunctive role for intraosseous endoscopy was developed. The author endoscopically identified avascular bone characterized by absent blood flow and correlated the location of this avascular bone with the preoperative MRI findings in patients with osteonecrosis. These intraoperative endoscopic findings were used to facilitate in the debridement of the femoral head up to the bleeding cancellous bone. This article describes a series of patients who underwent endoscopically guided thorough debridement and nonvascular autologous bone grafting with stabilization of the femoral head for the treatment of nontraumatic osteonecrosis (Steinberg stages 0 to IIIC). The diagnostic workup for osteonecrosis included a thorough history and physical examination, an anteroposterior pelvic radiograph, an anteroposterior and frog-leg lateral radiograph of the affected hip, and an MRI. Three patients (3 hips) in whom the MRI was considered nondiagnostic had a preoperative computed tomography (CT) scan.

After receiving institutional review board approval, preoperative, immediate postoperative, and follow-up anteroposterior radiographs, pre- and postoperative Harris Hip Scores (HHS), and patient clinical histories were evaluated. Ten of 16 patients (13 hips) were available for review at a minimum 2-year follow-up (range, 27-45 months) and are included in this study. Nine of these patients had a history of chronic steroid use for asthma, both of which are as risk factors for osteonecrosis. No additional risk factors could be identified. Eight men (10 hips) and 2 women (3 hips) were included in the study. Average age at the index procedure was 49 years (range, 34-58 years). Average preoperative HHS was 43 (range, 30-75), with 12 hips considered poor (HHS <70) and 1 hip considered fair (HHS 70-80). According to the Steinberg classification system, the hips were staged as follows: 1 hip at stage 0; 1 at stage IA; 4 at stage IIA; 3 at stage IIB; 1 at stage IIC; and 3 at stage IIIC (Table 1). Informed consent was obtained from each patient, and each report included a detailed

### Materials and Methods

Between November 2002 and July 2004 at the same institution, 16 patients (21 hips) underwent endoscopically guided thorough debridement and nonvascular autologous cancellous bone grafting with stabilization of the femoral head for the treatment of nontraumatic osteonecrosis (Steinberg stages 0 to IIIC). The diagnostic workup for osteonecrosis included a thorough history and physical examination, an anteroposterior pelvic radiograph, an anteroposterior and frog-leg lateral radiograph of the affected hip, and an MRI. Three patients (3 hips) in whom the MRI was considered nondiagnostic had a preoperative computed tomography (CT) scan.

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description of the index procedure having been performed by 1 surgeon (J.K.B.).

### Surgical Technique

Autologous cancellous bone and marrow were harvested from the ipsilateral iliac crest in all patients. A 3.2-mm guidewire (Orthopedic Sciences, Inc, Seal Beach, California) was passed into the femoral head and neck. When the preoperative MRI was nondiagnostic (Steinberg stage 0), the guide wire was passed into the center of the femoral head and neck. When the preoperative MRI was considered positive, the guide wire was directed toward the lesion on MRI. A handheld 8-mm internal diameter×9-mm outer diameter coring trephine was inserted up to the tip of the guide wire in the femoral head. Each core sample obtained had been marked to maintain its anatomic ori-

<table>
<thead>
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<th>Table 2</th>
<th>Steinberg Classification in Relation to Endoscopic Staging of the Femoral Head Avascular Burden</th>
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<tr>
<td><strong>Preoperative Steinberg Classification</strong></td>
<td><strong>Intraoperative Endoscopic Avascular Burden</strong></td>
</tr>
<tr>
<td>Stage 0</td>
<td>Normal or non-diagnostic radiographs, bone scan, and/or magnetic resonance imaging</td>
</tr>
<tr>
<td></td>
<td>A. Necrotic bone in 1 visual quadrant, up to 30% debridement required</td>
</tr>
<tr>
<td></td>
<td>B. Necrotic bone in 2 visual quadrants, up to 50% debridement required</td>
</tr>
<tr>
<td></td>
<td>C. Necrotic bone in more than 2 visual quadrants, &gt;50% debridement required</td>
</tr>
<tr>
<td>Stage I</td>
<td>Normal radiograph; abnormal bone scan/ MRI:</td>
</tr>
<tr>
<td></td>
<td>A. Mild, &lt;15% of head affected</td>
</tr>
<tr>
<td></td>
<td>B. Moderate, 15% to 30% of head affected</td>
</tr>
<tr>
<td></td>
<td>C. Severe, &gt;30% of head affected</td>
</tr>
<tr>
<td>Stage II</td>
<td>Abnormal radiograph; abnormal bone scan/MRI:</td>
</tr>
<tr>
<td></td>
<td>A. Mild, &lt;15% of head affected</td>
</tr>
<tr>
<td></td>
<td>B. Moderate, 15% to 30% of head affected</td>
</tr>
<tr>
<td></td>
<td>C. Severe, &gt;30% of head affected</td>
</tr>
<tr>
<td>Stage III</td>
<td>Subchondral collapse, crescent sign, without flattening:</td>
</tr>
<tr>
<td></td>
<td>A. Mild, &lt;15% of head affected</td>
</tr>
<tr>
<td></td>
<td>B. Moderate, 15% to 30% of head affected</td>
</tr>
<tr>
<td></td>
<td>C. Severe, &gt;30% of head affected</td>
</tr>
<tr>
<td>Stage IV</td>
<td>Flattening of femoral head:</td>
</tr>
<tr>
<td></td>
<td>A. Mild, &lt;15% of head affected</td>
</tr>
<tr>
<td></td>
<td>B. Moderate, 15% to 30% of head affected</td>
</tr>
<tr>
<td></td>
<td>C. Severe, &gt;30% of head affected</td>
</tr>
<tr>
<td>Stage V</td>
<td>Joint space narrowing and/or acetabular changes:</td>
</tr>
<tr>
<td></td>
<td>A. Mild</td>
</tr>
<tr>
<td></td>
<td>B. Moderate</td>
</tr>
<tr>
<td></td>
<td>C. Severe</td>
</tr>
<tr>
<td>Stage VI</td>
<td>Advanced degenerative changes</td>
</tr>
</tbody>
</table>

**Abbreviations:** CT, computed tomography; MRI, magnetic resonance imaging.

*A visual quadrant is ¼ of a clock face, extending from the medial end of the core track within the femoral head to the lateral extent of the core track within the femoral neck. For each endoscopic stage, the amount of debridement required to expose bleeding cancellous bone within the femoral head and neck is estimated and the hip is staged. If intraosseous endoscopy does not demonstrate avascular bone outside of the preoperative MRI lesion, the hip is staged according to the Steinberg classification system and the debridement required is estimated to be equal to the extent of involvement.
entation with respect to the femoral head. Simultaneously with fluoroscopy, a flexible 5.4-mm cystoendoscope (Olympus America, Melville, New York) was passed into the core track of the femoral head. Complete endoscopic visualization of the core track was achieved, and the presence and location (ie, anterior, posterior, superior, inferior, medial, and lateral) of densely sclerotic and nonporous avascular bone (bone with calcified marrow spaces) in regions of the femoral head and neck that did not coincide with the preoperative MRI findings were documented. Entry into the femoral head with the handheld coring trephine could create the observation of calcified marrow spaces; therefore, the core track was extensively irrigated and handheld probes were used to break impacted bone loose to ensure that what was observed endoscopically was native to the femoral head and not an artifact.

Seven- and 9-mm round high-speed burrs (Orthopedic Sciences, Inc) were then inserted into the femoral head to debride the avascular bone under fluoroscopic guidance. Importantly, visualization after debridement with several high-speed burrs demonstrated bone with calcified marrow spaces, confirming this observation as a true in situ finding. Sequential endoscopic visualization and debridement were repeated until bleeding porous cancellous bone was visualized.

Endoscopic white light imaging of cancellous bone that demonstrated no calcified marrow spaces was considered normal (Figure 1A),(10) whereas narrow band imaging accentuated the delicate intraosseous blood flow (Figure 1B). A contrast study (iohexol; Amersham Health, Buckinghamshire, United Kingdom) was performed to document the presence or absence of extravasation of contrast material into the joint space. The harvested autologous nonvascular cancellous bone was passed into the residual cavity of the femoral head. A reverse compression screw was then inserted into the core track, and rotated clockwise to compress

Figure 1: Intraosseous endoscopic view of porous cancellous bone in the femoral head after thorough debridement (Steinberg IIA, HHS was 34 preoperatively and 94 at 34 months postoperatively) using standard white light imaging. The marrow spaces (solid arrows) easily accommodate blood flow. Trabeculae (dashed arrow) (A). Narrow band imaging showing the delicate vasculature (white arrow) in the marrow spaces.

Figure 2: Anteroposterior (A) and lateral (B) radiographs of the right hip at 45 months postoperatively of the patient in Figure 6. The HHS was 41 preoperatively and 96 postoperatively. The compression screw (Hip Tool Implant; Orthopedic Sciences, Inc, Seal Beach, California) stabilizes the bone graft, allowing early range of motion at 3 weeks to promote cartilage nutrition during graft consolidation. The reverse compression screw is positioned in the region of Ward’s Triangle. Currently in a different patient, the author positions the head of the reverse compression screw (white arrow) in the center of the femoral head (C). Doing so facilitates continued decompression of the femoral head with simultaneous stabilization of the bone graft, as does a free vascularized fibula graft.

Figure 3: Plain anteroposterior radiograph that was interpreted as negative (A). T1-weighted magnetic resonance image that was initially read as nondiagnostic but is now recognized as having a signal pattern in the femoral head called mixed-signal heterogeneity (B). Axial computed tomography scan of the same hip in Figure 3A. The signal changes in the center of the femoral head are consistent with cortical bone (ie, central sclerosis or a starburst pattern). In the current series, this disease pattern is consistent with atypical osteonecrosis. The intraosseous endoscopic appearance of this femoral head is shown in Figure 4. Calcification exists in the marrow spaces (C).
and stabilize the bone graft (Figure 2). All patients were instructed to remain non-weight bearing and to begin physical therapy at 2 weeks postoperatively, followed by progressive weight bearing beginning at 6 weeks postoperatively.

RESULTS

Twelve of the 13 hips that underwent the index procedure had a positive preoperative MRI. The Steinberg stage 0 hip had a normal radiograph (Figure 3A) and an unremarkable MRI (Figure 3B). The authors obtained a preoperative CT scan (Figure 3C) that demonstrated focal sclerosis in the central portion of the femoral head. This signal change on the CT scan was considered a starburst sign. All 13 hips demonstrated densely sclerotic avascular bone on intraosseous endoscopy in areas in the femoral head and core track that did not coincide with the necrotic bone identified on the preoperative MRI. The Steinberg stage 0 hip demonstrated diffusely sclerotic bone due to calcification in the marrow spaces throughout the entire core track (Figure 4). Histologic analysis of the specimens obtained from areas in the femoral head that did not coincide with the preoperative MRI findings confirmed osteonecrosis in 13 hips. Plain radiographs of a painful hip were used preoperatively (Figure 5A), and intraosseous endoscopy allowed direct visualization and localization of the avascular bone in the femoral head and neck (Figure 5B). Endoscopic localization of the avascular bone allowed for its debridement using a minimally invasive technique. Debridement was considered complete and thorough when porous bleeding cancellous bone was substantially observed endoscopically throughout the residual cavity in the femoral head and neck (Figure 5C).

The mean preoperative HHS was 43 (range, 30-75) and improved postoperatively to a mean of 93 (range, 60-100) with a mean follow-up of 35 months (range, 27-45 months). Eleven hips were considered excellent (range, 90-100), 1 was considered fair (range, 70-80), and 1 was considered poor (range, <70) (Table 1). Evidence existed of disease progression in 2 hips considered fair and poor: the fair hip demonstrated 2 mm of collapse (Steinberg stage IIA, HHS of 34 preoperatively and 60 at 34 months postoperatively), whereas the postoperative HHS of the contralateral hip was 94 at 34 months postoperatively. The poor hip demonstrated 3 mm of collapse (Steinberg IIC, HHS of 44 preoperatively and 75 at 30 months postoperatively). No infections occurred in the operated hips. After the index procedure, all 10 patients (13 hips) were fully ambulatory by 10 weeks. Each hip that underwent the index procedure demonstrated new bone formation in the femoral head as evidenced by remodeling of the bone graft. Eleven of the 13 hips demonstrated no radiographic evidence of collapse.

Using intraosseous endoscopy to visualize the residual cavity after thorough debridement facilitated estimating the extent of debridement required as a percent above the extent of involvement according to Steinberg. It was estimated that up to an additional 20% or more of the femoral

![Image](https://example.com/image1)

![Image](https://example.com/image2)

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![Image](https://example.com/image10)
head and neck would be removed if avascular bone identified on intraosseous endoscopy did not coincide with the preoperative MRI. Thus, a Steinberg stage IIC lesion might require removal of up to 50% of the bone in the femoral head and neck (>30% involvement for a Steinberg stage C lesion on MRI and an additional 20% of endoscopically identified avascular bone) to effect thorough debridement. Bone observed endoscopically was considered avascular when its marrow spaces were occluded. Thoracic debridement comprised enlarging the core decompression track up to a bleeding host bed of porous cancellous bone.

**Discussion**

Since the characterization of elevated intraosseous pressure (>30 mm Hg) in the femoral head of patients with osteonecrosis by Ficat,11 core decompression has been considered a treatment option for early-stage osteonecrosis. The pain relief experienced by the patients in the Ficat11 series combined with a decrease in the recorded intraosseous pressure led to the ongoing recommendation of core decompression for the treatment of early-stage osteonecrosis. However, within a given early stage, outcomes following core decompression have varied, from as low as 17% (7 of 41 in the series reported by Learmonth et al12) and as high as 89% (119 of 133 in the series by Ficat11), and mitigate against the adoption of a consensus of opinion and the consideration of joint preservation procedures that expand on the principles of Ficat.11

In a series of 40 hips, Camp and Colwell3 observed 3 subtrochanteric femur fractures, a 60% failure rate for Ficat stages 1 and 2, and concluded that core decompression using a 10-mm trephine should be considered “a relatively ineffective procedure with significant morbidity.” To understand these variable outcomes following core decompression, Steinberg et al4 used MRIs to modify the system of Ficat11 and expanded it into 7 stages (stages 0 through VI) and quantified the extent of involvement: A, <15%; B, 15% to 30%; or C, >30%, for stages I through V (Table 2). Mont et al13 further correlated outcomes with the extent of involvement in their retrospective literature review of 1166 hips: 84% survival for stage I, 64% survival for stage II, and 47% survival for stage III. Steinberg et al4 offered a linear way of thinking about osteonecrosis by stratifying the outcomes; however, their work did not address the variability in outcomes in a given stage. Therefore, a broader understanding of the pathophysiology of disease is still needed to improve the selection of patients for joint preservation.

Calder et al14 demonstrated increased immunohistochemical staining for inducible nitric oxide synthase in 15 retrieved femoral heads of patients undergoing total hip arthroplasty for advanced steroid- and alcohol-induced osteonecrosis. Twenty similarly retrieved control hips with advanced osteoarthritis demonstrated no increased staining for inducible nitric oxide synthase (P<.001). The 15 femoral heads with increased staining for inducible nitric oxide synthase demonstrated no increased staining for inducible nitric oxide synthase demonstrating DNA laddering, indicating that cell death was accompanied by apoptosis. During apoptosis, inflammation is absent; thus the detection of fluid changes that would suggest disease on MRI may be uncertain.

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**Figure 6:** Anteroposterior radiograph of the pelvis showing that the central portions of both femoral heads are consistent with sclerosis (white arrows).

**Figure 7:** T1 magnetic resonance image of the patient in Figure 6 showing necrotic lesions (solid arrows) consistent with a diagnostic magnetic resonance image. The right hip was classified as Steinberg IIA and the left hip as Steinberg IIB (A). Intrarosseous endoscopic view showing a significant avascular burden in the antecedent core track and calcification in the marrow spaces (arrow) (B). A thoroughly debrided core track with good residual porous bleeding cancellous bone sufficient enough to supply the autograft. The small lesion (solid arrow) on the preoperative magnetic resonance image (A) is observed in the most medial extent of the residual cavity (C). A sclerotic margin, corresponding with the left hip (solid arrows) (A). Avascular bone with calcified marrow spaces (dashed arrows) and subchondral bone (lollypop) are shown (D).
Furthermore, the endoscopic observation of calcified marrow spaces (Figure 4A) suggests that dying adipocytes may be associated with saponification of marrow fat with its subsequent calcification. Histologically, one would observe dystrophic calcification of the bony trabeculae with occlusion of marrow spaces (Figure 4B) and encroachment of the intraosseous blood flow. Calcification (dystrophic) and ossification (repetitive fracture repair response) lead to the sclerotic changes often observed on plain radiographs (Figure 5A), and when associated with instability (collapse), intraosseous nonunion occurs.

In the current series of 13 hips, avascular bone undetected on preoperative MRIs was detected with the use of a flexible endoscope. Endoscopic localization of the undetected avascular bone facilitated thorough debridement of the femoral head. Thorough debridement of the femoral head in the treatment of osteonecrosis is consistent with the work of Urbaniak et al., Rosenwasser et al., and Mont et al. One hundred percent of the hips evaluated endoscopically in the current series demonstrated visual evidence of avascular bone that was confirmed as necrotic on histology. This necrotic bone did not coincide with the necrotic bone on the preoperative MRI. This was particularly important in the patient who had a nondiagnostic preoperative MRI (Figure 3B). This case was considered atypical osteonecrosis, and the author calls the findings on this MRI mixed-signal heterogeneity.

Knowing the location of the endoscopically visible avascular bone in situ allowed safe expansion of the core decompression track to effect thorough debridement. Eighty-five percent of patients (11 of 13 hips) demonstrated a good to excellent outcome at a minimum of 2 years follow-up (range, 27-45 months). The detection of avascular bone in situ that does not coincide with necrotic bone on preoperative MRI is of clinical relevance when selecting patients for joint preservation and supports the work of Calder et al., wherein these investigators suggested a noninflammatory basis for the pathophysiology of alcohol- and steroid-induced disease. The inability to identify the full extent of necrotic bone on MRI (ie, disease, not involvement) in the femoral head could lead to variable outcomes in a given early stage if such patients are selected for core decompression alone based solely on the MRI findings.

Figure 6 is a radiograph of 54-year-old man with bilateral hip pain, and Figure 7A is the corresponding MRI. Although this patient could have been selected for core decompression alone based on the Steinberg stage, the avascular bone observed endoscopically after core decompression (Figure 7B) could have affected the outcome because adequate blood flow through the marrow spaces was not restored after core decompression alone (Figures 7B, 7C). Trabecular bone without blood flow is avascular, and such bone is pathologic to the extent that its presence is associated with chronic hip pain. Furthermore, the observation of empty lacunae, which is required to make a histologic diagnosis of osteonecrosis, represents how the surrounding host bed has responded to a segment of avascular bone (ie, phagocytic removal of dead osteocytes).
Critical to this observation is a requirement for blood flow at the margins of the avascular bone. When blood flow varies substantially between the brittle avascular bone and the ductile porous bone, intraosseous fractures occur at the necrotic bone host bone junction and MRI changes will meet diagnostic criteria for osteonecrosis. However, avascular bone may elude detection on MRI and be characterized as mixed-signal heterogeneity when the blood flow has been compromised slowly. In the current study, the pattern of calcification in the marrow spaces was also observed after thorough debridement (Figure 7D), confirming that this observation was not an artifact. Although the current series comprised 9 patients who abused alcohol and 1 patient with steroid-associated disease, Brannon\textsuperscript{19} reported calcified marrow spaces in a patient with osteonecrosis of the shoulder (Figure 8).

The technique of endoscopically guided core decompression broadened the current author’s understanding of osteonecrosis in view of the work of Pugh et al,\textsuperscript{20} wherein these investigators hypothesized that bone changes (ie, increased contiguity) may precede and influence the destruction of the overlying cartilage. It is possible that avascular bone could stress the overlying cartilage and lead to degenerative joint disease over time. Therefore, the increased contiguity of the trabecular bone described by Pugh et al\textsuperscript{20} could not be observed until the femoral head was resected for arthroplasty; thus, the temporal relationship between bone destruction and cartilage destruction in hip disease has never been characterized.

The current author used flexible intraoperative endoscopy on early- and late-stage osteonecrosis to gain new information on this disease to understand why outcomes may vary substantially when core decompression is the selected treatment. Avascular bone was observed that did not coincide with the preoperative MRI in all of the current study patients, suggesting that this change in femoral head blood flow may not induce known MRI changes diagnostic for osteonecrosis. Therefore, avascular bone not circumscribed by a sclerotic margin may remain undetected whether disease is staged as early or late.

The observation of calcified marrow spaces in the femoral head in the current patient with a nondiagnostic MRI for osteonecrosis further supports this view. By endoscopically identifying substantially all avascular bone in the current patients, thorough debridement was achieved in each case. Thus, the T2-weighted MRI of the patient in (Figure 3B) was considered to be representative of mixed signal heterogeneity, a pathologic finding. Although mixed-signal heterogeneity describes a diffuse pattern of calcified trabeculae having occluded marrow spaces (avascular bone), the term sclerotic margin implies circumscription, ie, localization of necrotic bone.

Steinberg et al\textsuperscript{4} relied on the presence of a sclerotic margin to quantify the extent of involvement. However, understanding why outcomes may vary in patients with early-stage disease is more relevant to improving patient selection for joint preservation. Although the preoperative MRI is helpful when it is positive, a nondiagnostic MRI does not rule out the presence of disease in patients with chronic hip pain and a CT scan should be considered. More importantly, when core decompression is chosen for treatment, one should consider how residual avascular/necrotic bone could affect the outcome, particularly when the full extent of disease (the avascular burden) is not fully appreciated on the preoperative MRI. The invasive thorough debridement surgical approaches of Urbanik et al,\textsuperscript{16} Rosenwasser et al,\textsuperscript{17} and Mont et al\textsuperscript{18} effectively remove almost all avascular bone without having to identify it. Consequently, a clinical opportunity of understanding the pathophysiology of disease beyond what is known and what may be grossly obvious on MRI is bypassed. However, 86% of patients (13 of 15 hips) in the Rosenwasser et al\textsuperscript{17} study were asymptomatic at a mean of 12 years (range, 10-15 years) and 83% of patients in the Mont et al\textsuperscript{18} study (20 of 24 stage III hips) had a good or excellent outcome at a mean of 56 months. In the current study, 85% (11 of 13) of patients achieved a good to excellent outcome, albeit at 2-year follow-up. The current results approach those of Rosenwasser et al\textsuperscript{17} and Mont et al\textsuperscript{18} to the extent that thorough debridement portends a good outcome. Long-term follow-up is required to determine the sustainability of the current results and represents the major weakness of the study.

**CONCLUSION**

Stabilization of the bone graft in the current series allowed early range of motion, promoting cartilage nutrition during the nonweight-bearing phase of recovery, and is consistent with the basic science of new bone formation.\textsuperscript{21} The images obtained in the current study allowed the author to develop a suggested approach to nontraumatic osteonecrosis of the femoral head (Figure 9).

**REFERENCES**


