Color Doppler Imaging Assessment of Blood Flow in Vascularized Pedicle Grafts for Avascular Necrosis of the Femoral Head: Angiographic Correlation

Jochen Duchow, MD, Rainer Kubale, MD, Thomas Hopf, MD

The aim of this study was to examine whether color Doppler imaging can be used to assess vascular patency after use of pedicle pelvic bone grafts in the operative treatment of avascular necrosis of the femoral head. We performed color Doppler imaging and selective angiography in 10 consecutive patients (12 hip joints) treated for avascular necrosis of the femoral head. In comparison to angiographic results, nine patent and two occluded grafts were demonstrated correctly by color Doppler imaging. In one case, a graft confirmed as patent by angiography was not demonstrable by color Doppler imaging. Accuracy, sensitivity, and specificity of color Doppler imaging were high when compared to angiography as a standard. Color Doppler imaging is suited to evaluate vascular patency after use of vascularized pedicle bone grafts in the treatment of avascular necrosis of the femoral head. KEY WORDS: Color Doppler imaging; Angiography; Bone grafts, vascularized pedicle; Transplants, perfusion.

SUBJECTS AND METHODS

From 1993 to 1995, 10 consecutive patients (12 hip joints) treated for AVN of the femoral head by pedicled bone grafts originating from the anterior iliac crest were assessed postoperatively. CDI was carried out 3 to 6 months after the operation using an Ultramark 9 HDI (Advanced Technology Laboratories, Bothell, WA) with a 5 MHz linear transducer. Examinations were performed nonblinded by two physicians routinely involved in CDI. With the
in supine position the femoral artery was visualized just distal to the inguinal ligament. If possible, the DCIA was then demonstrated at its origin and followed to the femoral neck. If this was not feasible, the vessel was sought close to the transplanted bone graft ventral to the femoral neck. Visualization of flow at the ventral femoral neck was set as the criterion for vessel perfusion.

Selective angiographic studies were performed during routine follow-up examination 2 to 5 months after the operation. Time range between angiographic studies and CDI was 1 to 4 months.

RESULTS

Nine of the 10 patent grafts as confirmed by angiography were correctly demonstrated by CDI. In seven cases the vessel could be followed from its origin to the graft implantation site at the femoral neck (Fig. 1). Figure 2 shows the corresponding Doppler sonographic tracing. In two patients the DCIA could be identified only near the graft close to the ventral femoral neck. Owing to the small diameter of most of the transplants a reproducible quantification of flow (Doppler tracing) was not possible. An example of a typical postoperative angiogram is shown in Figure 3 (same patient as depicted in Fig. 1); note the absence of major vessels in the region of the ventral femoral neck, which could possibly hinder the sonographic examination or identification of the transplanted DCIA.

In one case, a graft confirmed as being patent by angiography was not demonstrable by means of CDI. In this patient, sonographic examination was hindered by periarticular calcifications, which made proper demonstration of the ventral femoral neck anatomy difficult.

Neither occluded graft as confirmed with angiography could be demonstrated correctly with CDI (Table 1).

Figure 1 CDI sequence from the left hip joint in one representative patient shows the femoral artery just distal to the inguinal ligament (a) with the DCIA leaving the femoral artery laterally, first ascending (b), then descending to the ventral femoral neck (c).
DISCUSSION

Bone grafting using pedicled bone grafts is a currently used joint-preserving operative procedure in the treatment of AVN of the femoral head. We used a corticocancellous graft derived from the anterior iliac crest with its blood supply coming from the DCIA.\textsuperscript{8,9} This graft is implanted into the ventral femoral neck after curettage of the necrotic area in the femoral head and filling of the defect with cancellous bone. The postoperative assessment of transplant perfusion is crucial to the further clinical evaluation of the method; other treatments consist of core decompression or curettage and filling of the defect with cancellous bone alone.\textsuperscript{4,5,10} We have used selective angiography routinely to evaluate graft perfusion after surgery.

The results of this nonblinded study suggest that CDI is a useful means in the assessment of postoperative transplant perfusion after pedicled bone grafting of the hip joint. Other investigators, too, have used CDI successfully to evaluate transplant perfusion after different operative procedures, such as those involving the latissimus dorsi and transverse abdominal myocutaneous flaps.\textsuperscript{11,12} In comparison to routinely performed angiography as a standard, CDI achieved high levels for sensitivity, specificity, accuracy, and positive predictive value.

In the single false-negative ultrasonographic result, the sonographer was unable to visualize the area of interest successfully well owing to massive periarticular calcifications. This case clearly demonstrates the limitations of CDI. In such a setting, thorough assessment of routine radiographs should indicate the need to perform angiography and thereby prevent futile attempts to localize the transplant by means of CDI.
As a noninvasive method, CDI is a feasible alternative to conventional angiography in the specific setting of perfusion assessment after pedicled pelvic bone grafts. The ease of repeating examinations during postoperative follow-up study is an argument for its use. Whether the data concerning transplant perfusion correlate with the long-term clinical outcome will help to judge the operative procedure as such.

**Table 1: Comparison of CDI and Angiography**

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<td>CDI</td>
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*Results of postoperative perfusion assessment of the transplanted DCIA by CDI and selective angiography (n = 12 hip joints in 10 patients; table displays data of matched cases). For detection of flow CDI has a sensitivity of 90%, a specificity of 100%, an accuracy of 92%, a positive predictive value of 100%, and a negative predictive value of 66%.

**REFERENCES**


**Figure 3** Angiogram of the left DCIA in cross-over shows the postoperative anatomy; the vessel can be followed from the femoral artery in a curved manner to the femoral neck. No other arteries with a similar diameter can be seen close by.