Evolving Technologies: New Answers or New Problems?
Back to the Future: Evolution in Hip Design

John J. Callaghan, MD
Thomas D. Brown, PhD

Total hip arthroplasty procedures have been performed in the United States for approximately 3 decades. During that time, a number of design features have been introduced into the procedure. This study evaluated changes in the total hip arthroplasty procedure that were thought to be advances but have been abandoned because the original or previous design feature has proven to be more effective.

MATERIALS AND METHODS
The following are some areas of total hip arthroplasty construct that have undergone changes in design over the 30-year experience with the procedure in the United States.
- femoral head size,
- liner geometry,
- newer polyethylenes,
- metal-on-metal articulations,
- modularity,
- acetabular fixation: cemented and cementless,
- cementless acetabular fixation: screws and no screws,
- cemented femoral design: smooth and rough,
- cement mantles: small or large,
- cementless femoral fixation: extensively coated or proximally coated, and
- resurfacing arthroplasty.

RESULTS
Femoral head sizes were originally small with the Charnley design. The potential for better contact area and greater motion before impingement led to the use of larger head sizes. Long-term radiographic data, autopsy retrievals, and basic science work have demonstrated less wear with smaller head sizes.1-4

Originally, Charnley switched to a posterior lip liner to prevent dislocation. Most designs with larger head sizes returned to nonextended lip liners. Recent reports demonstrate the potential benefit of extended lip liners in reducing dislocations.5

The original ultra-high molecular weight polyethylene was introduced by Charnley after the failure with Teflon. Attempts at enhancement of polyethylene by the use of carbon fiber and other enhancing processes have not been improvements.6 Manufacturers are returning to regular ultra-high molecular weight polyethylene, and benefits of crosslinking from irradiation are also under investigation.

The original McKee-Farrar metal-on-metal prosthesis was abandoned for polyethylene-metal articulations because of the success of the latter. Early failures of this device also occurred because of suboptimal femoral component design. Successful long-term results of the original design have demonstrated little wear. A number of manufacturers are reexploring the use of metal-on-metal articulations.7

Monolithic stems were originally used and modified to prevent early femoral neck impingement. Modular connections, which were introduced in
the early 1980s, enabled the surgeon to have multiple intraoperative options. However, problems with corrosion and wear at modular connections have led some surgeons to reconsider monolithic component options.8-10

Cemented acetabular fixation was initially successful but deteriorated over time. Cementless acetabular fixation became the gold standard. An increase in acetabular component wear and acetabular osteolysis with some designs has led to the resurgence of cemented acetabular fixation.11

The most successful first-generation cementless acetabular components were augmented with screw fixation. The concerns with screw holes and screw fretting led to the use of pressfit fixation without screws. Potential for acetabular fracture and early or late component instability have led to the return of screw augmentation of cementless devices by many surgeons.12-14

The original Charnley cemented femoral component had a smooth polished texture. Rougher surfaces were introduced to better bond the prosthesis to cement. Early failure has been noted with these textured stems, probably related to their abrasive characteristics when the stem becomes debonded from cement. Surgeons are returning to the use of femoral components with smoother polished surface finishes.15,16

Originally, Charnley promoted large cement mantles especially proximal medially and distal laterally in the femoral construct. His cobra-shaped proximal design was intended to centralize the component in the proximal femoral canal. Most surgeons left this concept for larger femoral components with smaller cement mantles. More recently, surgeons and investigators have appreciated the benefit of femoral component centralization and circumferential cement mantles.17

In cementless femoral fixation, extensively porous-coated stems were originally used. Concern for stress shielding and the inability to remove intact implants led to the widespread use of proximally (many times noncircumferentially coated) porous-coated devices. The excellent long-term track record with extensively coated devices as well as the decreased concern of stress shielding and the ability to safely remove intact extensively coated femoral components have led many surgeons to return to the use of more extensively coated devices.18

Finally, resurfacing arthroplasty, after a short period of popularity, was abandoned because of unacceptable early revision rates. However, the use of hemiresurfacing has increased for the difficult osteonecrosis patient with stage 3 Ficat involvement.19

**DISCUSSION**

Many of us in the total hip arthroplasty field are always looking for new technologies that may help provide a more durable construct to increase the longevity of the arthroplasty for our patients. Fortunately, in this field, the results of these changes are closely monitored with regular follow-up of our patients. Although we are always looking for better alternatives for our patients, we should first ask what is working in total hip arthroplasty before asking what is new in total hip arthroplasty.

**REFERENCES**