The Rationale For A Collared Titanium Stem In Primary Total Hip Arthroplasty

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Introduction
In today’s changing healthcare environment, surgeons are striving to deliver long term clinical results, while also meeting the needs of their patients within the ninety day episode of care window. In the current North American market, many total hip arthroplasty patients are treated with titanium, tapered press-fit stems. While the design features vary across different stem options, the collared and collarless design feature has sparked the most discussion among health care professionals. The rationale for a collarless cementless implant design originated over thirty years ago. Theoretically, a collarless tapered stem will find its position of optimal stability both intraoperatively with impaction, as well as postoperatively with weight bearing. Designers hypothesize that a collar may prevent the stem from finding its optimal position, leading to micromotion and failure of biological fixation. While collarless stem designs have demonstrated decades of clinically successful survivorship, there are several considerations to be mindful of when evaluating stem performance under the conditions created by modern advances in total hip arthroplasty treatment protocols.

Surgical Approach
The earliest surgical approach used for primary total hip arthroplasty was a transtrochanteric approach, and over time, the posterolateral and direct lateral approaches have become more widely utilized. With traditional approaches such as these, the abductor muscle is compromised during surgery, resulting in a potential reduction in early patient activity and weight bearing. Since 2005, the Anterior Approach has gained significant popularity, and by some estimates may represent thirty percent of total hip arthroplasty procedures performed today. There are advantages in avoiding detachment of the abductor or iliotibial band, with multiple studies demonstrating that anterior approach patients experience less postoperative pain, walk earlier, and discontinue use of an assistive device sooner after surgery, compared to traditional approaches. While some studies have only shown subtle differences in outcomes between approaches, each subsequent improvement in our ability to mobilize patients imposes additional stresses on the femoral implant.

Bone Quality
As the age range of THA candidates has expanded over time, more elderly patients are being treated with total hip arthroplasty, with reports confirming acceptable complication rates in octogenarians and nonagenarians. Additionally, it has become increasingly common for surgeons to treat hip fracture patients with cementless stems. This subset of patients is known to have reduced bone quality and a higher rate of osteoporosis. One study reports on forty-six trauma patients with a mean age of seventy-one who underwent cementless THA with a collarless stem. Compared to patients treated with total hip arthroplasty for osteoarthritis, the stems placed in the trauma patients subsided significantly more (mean 4.27 mm vs 1.57 mm, p=0.001). Three of the forty-six patients required revision for subsidence within the first six months compared to zero revisions at six months in the osteoarthritis group.

Perioperative Patient Protocols
When cementless stems were first implanted in the early 1980s, the perioperative protocols were quite different than today. Patients experienced hospital stays of five to ten days, and were initially kept on bedrest, followed days later by a slow and incremental mobilization protocol. When allowed to walk, patients were kept to partial weight bearing with a walker or crutches, a restriction that was typically enforced for up to six weeks. Perioperative pain was controlled with modalities such as indwelling epidural catheters and IV narcotics often administered by patient controlled pumps, both of which slowed patient mobilization and early activity. Most surgeons imposed hip precautions, limiting range of motion and subsequently reducing activity. Worries about bearing surface wear led surgeons to instruct patients to avoid higher levels of activity. These factors reduced the overall stress on the implant, lowered micromotion, and helped achieve successful biological fixation, with low rates of subsidence.

With the introduction of multimodal pain protocols, combined with rapid recovery principles, patients now are routinely walking on the day of surgery, often with only a cane. Pain levels have been reduced to the point that many patients use little, if any, IV narcotic
medication. Surgeons have gradually eliminated historical hip precautions, removing barriers to patients increasing their activity levels. As bearing couplings have been improved and studies have shown reduced wear rates, surgeons have lifted restrictions, and many now allow their patients to engage in more intensive activities such as running or jumping sports. Some centers have advanced to the point of performing outpatient hip replacements, requiring that patients walk in their home environment on the day of surgery.

In a 2008 report, subsidence rates were measured in patients treated with collarless, tapered titanium stems and modern postoperative protocols. The authors observed significant rates of subsidence at one year, with ten percent of hips having subsided by over three millimeters. A higher rate of subsidence in males versus females (mean 1.7 mm vs 1.0 mm, p=0.03) was reported. Additionally, males were found to have lower outcome scores at the one year timeframe, and over four percent of the male patients required revision for loosening.

For a cementless femoral stem to obtain biological fixation, early micromotion between the bone and stem must be low. If micromotion does occur, the stem will fail to gain stability, potentially leading to fibrous fixation, loosening, subsidence or periprosthetic fracture. Recently, authors have reported increased rates of subsidence leading to instability, periprosthetic fracture, and loosening. The increased stresses and aggressive postoperative protocols may contribute to these complications. Because of the numerous factors that have changed in today’s THA environment, a collarless stem design may not be appropriate for all patients.

Why Use a Collar?
The rationale for designing a cementless femoral stem with a collar is to improve the chance that the stem will stay in the exact position it was placed, reduce the chance of subsidence, lower early micromotion, and increase the rate of biological fixation. Lower subsidence rates can potentially mitigate the risk of periprosthetic fracture, as well as reduce the risk of leg length discrepancies and patient dissatisfaction. The addition of a collar can help achieve stem stability, with the goal to have the stem stay in the position it was placed intraoperatively.

Does a Collar Work?
There is evidence to demonstrate that the addition of a collar can improve overall stem stability. In a cadaveric study, forty femoral stems (CORAIL® Hip System, DePuy Synthes) were implanted in twenty bilateral specimens, with one femur implanted with the collarless stem, and the other femur implanted with the collared stem of the same design. Forces in the vertical and horizontal plane were then measured to determine the force required to cause subsidence and eventual fracture. In the vertical plane, the force required to cause both subsidence and fracture was significantly higher in the specimens with a collared prosthesis. Similarly, in the horizontal plane, subsidence and fracture occurred at significantly higher levels with the collared prosthesis. The authors concluded that with this stem design, the collar allows the stem to withstand significantly greater forces before subsiding and fracturing.

In a cadaveric study of a recently launched cementless triple taper design (ACTIS™ Hip System, DePuy Synthes), a collared version of the stem was compared to a collarless prototype version of the same stem, as well as a collarless stem with an excellent track record (SUMMIT® Hip System, DePuy Synthes). After application of a force consistent with a one-legged stance phase of gait, the collared stem showed the lowest migration, mean cyclic amplitude, and highest mean force to failure.

While cadaveric studies have supported the rationale for a collar on a press-fit device, it will be important to follow the clinical outcomes of cementless collared stems.

Conclusion
As advancements in total hip arthroplasty have allowed for patients to weight bear shortly after surgery and experience quick recoveries, there is an increased need for implants to achieve both immediate and long term stability. Cadaveric studies and case examples, such as those provided on the following page, have shown that a collar can help provide improved initial axial and rotational stability, prevent subsidence, and protect occult fractures. Additionally, the collar can provide stability to help the stem stay in its intraoperative position.
Case Studies

The following case studies provide examples of when a cementless, collared stem may prove to be beneficial in total hip arthroplasty. Case 1 demonstrates an early periprosthetic fracture following THA with a flat, tapered-wedge collarless stem. Cases 2 and 3 illustrate periprosthetic fractures with both collared and collarless versions of the same stem design. Although periprosthetic fractures can occur regardless of stem design, in the case of the periprosthetic fracture with the collared stem, the patient was able to be treated with a conservative non-weight bearing protocol, thus eliminating the need for revision surgery.

Case 1

Figure 1 shows the final implantation of a flat tapered-wedge collarless stem, followed by an early periprosthetic fracture (Figure 2). A flat tapered-wedge stem without a collar, while successful a high percentage of the time, can be more susceptible to subsidence and fracture due to lower intrinsic stability.12

Case 2

Figure 3 illustrates a collarless CORAIL Hip Stem. After suffering a fall four weeks post-op, the periprosthetic fracture (Figure 4) required a stem revision (Figure 5). The absence of the collar may have allowed for stem subsidence and fracture displacement.

Case 3

Figure 6 illustrates a collared CORAIL Hip Stem. Five weeks post-op, the patient was admitted for acute hip pain, and it was discovered that the stem had subsided and fractured proximally (Figure 7). The patient was treated with protected weight bearing and healed uneventfully (Figure 8). The collar may have prevented further stem subsidence and improved stem stability, overall eliminating the need for revision surgery.
References:


