Modular Versus Nonmodular Femoral Necks for Primary Total Hip Arthroplasty

Joshua T. Carothers, MD, Michael J. Archibeck, MD, and Krishna R. Tripuraneni, MD

Abstract

In total hip arthroplasty (THA), proximal femoral neck stem modularity (PFNSM) has theoretical advantages over nonmodular stems, including the ability to more closely reconstruct anatomy and improve stability. However, risks of metallosis and breakage at the junction must be considered.

In this study, we compared the head centers of a modular neck system with that of its nonmodular counterpart. Of 463 primary THAs with a modular stem, 261 (56%) had a head center equivalent to that of its nonmodular counterpart, and an additional 132 (29%) had a head center within 4 mm in length and 2 mm of offset. Thus, only 70 stems (15%) had a head center that was more than 4 mm in length and more than 2 mm in offset different from the nonmodular stem. Only 12 stems had a verted neck.

These findings suggest that, in a majority of primary THAs, use of a modular stem results in head center positions also achievable with a nonmodular stem. Given the risks of modularity, PFNSM should be used with caution. We recommend PFNSM in cases that cannot be reconstructed with the nonmodular option.

Femoral stem modularity in total hip arthroplasty (THA) has a checkered past. Developments such as the modular head–trunnion interface, which allows for placement of femoral heads of different sizes and offsets, and the modular midstem, which allows for version adjustments independent of patient anatomy (S-ROM, Depuy) and for bypassing proximal bone defects in the revision setting (Restoration Modular, Stryker; ZMR-XL, Zimmer), have proved very successful.[1-10] However, even these successful advances have been associated with failures at the modular junction.[11-13] Proximal femoral neck–stem modularity (PFNSM) has had mixed results, with notable failures and recalls associated with the neck–stem junction.[14,15] Failures at this junction have occurred secondary to corrosion and breakage of the modular neck.[16-18] Nevertheless, proximal modular stems remain available for implantation. One such system, the M/L Taper stem with Kinectiv technology (Zimmer), is an all-titanium construct that allows for adjustment of several variables (length, offset, version), providing numerous combinations beyond those of the original M/L Taper offerings. Advantages of these offerings include closer reconstruction of patient anatomy, stability improvements, and easing of the process of revision in polyethylene/femoral head exchanges or in infections in which single-staged irrigation and débridement and polyethylene/head exchange are chosen.

These theoretic advantages must be judged in the context of the possible disadvantages of the modular neck junction. The mechanical environment of the junction places it at risk for failure as well as for metallosis from fretting, crevice corrosion, and recurrent repassivation.[19] Although the titanium necks are at less risk for degradation than their cobalt-chromium counterparts, they are at higher risk for breakage.[13,19] For one of the surgeons in our practice, the M/L Taper stem with Kinectiv technology is the stem of choice for primary THA.

We conducted a study to determine, in the setting of primary THA, how often a neck–stem combination choice resulted in a reconstructive geometry that would not have been possible had the surgeon opted for the traditional M/L Taper stem. Every Kinectiv stem has numerous neck options with a head center position that would not be possible with the nonmodular M/L Taper. However, in a high-volume community practice, how often is a modular neck that results in an otherwise unavailable head center being used for the reconstruction?

Materials and Methods

This study was approved by our local institutional review board. The Kinectiv stem is used by 1 of the 4 high-volume joint replacement surgeons in our practice (not one of the authors). From our community practice joint registry, we identified every stem–neck combination used since the Kinectiv stem became available in 2006.[20] Each case was performed using a posterior approach. A trabecular metal acetabular component (Zimmer) secured with 2 screws was used, and an M/L Taper stem with Kinectiv technology was implanted in each case.

Once the neck–stem combination was determined, its position on the head centers map was compared with that of the standard M/L Taper head centers (**Figures 1, 2**) for each stem size as the relationship of the Kinectiv head center varies with each stem size compared with the head center of the M/L Taper stems. If the head centers were in contact on the

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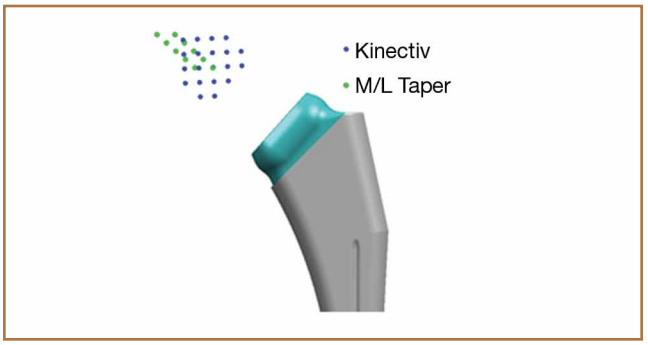

Figure 1. Femoral head center map for size 7.5 Kinectiv and M/L Taper (standard, extended-offset) stems. Image provided by Zimmer.

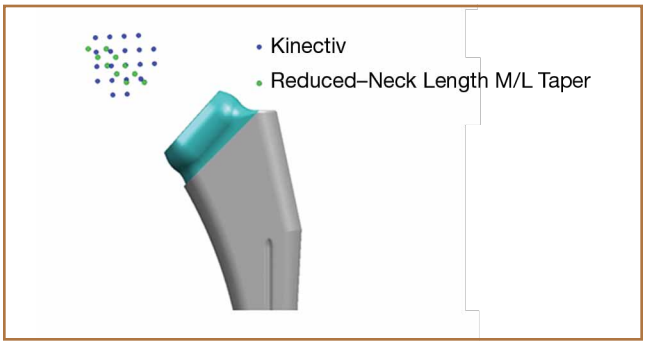

Figure 2. Femoral head center map for size 7.5 Kinectiv and M/L Taper reduced-neck (standard, extended-offset) stems. Image provided by Zimmer.

map, the geometry was considered identical. If the head centers were not in contact, we noted where the nearest standard M/L Taper head center lay in terms of length and offset. As the head centers are laid out in regular, 4-mm increments, this estimation was relatively easy. Any anteverted or retroverted neck was considered to have no adequate substitution in the standard M/L Taper stem offerings. This initial evaluation was performed by Dr. Carothers.

We then reviewed the head center comparisons independently. For every Kinectiv head center that did not contact an M/L Taper counterpart, the difference between those head centers was reviewed. Each of us noted whether the difference between the head centers was clinically relevant, as many of the head center positions are extremely close. The head centers that were so close as to be deemed clinically irrelevant were recorded.

Results

Between January 2008 and October 2013, 463 primary THAs were performed using the M/L Taper femoral stem with Kinectiv technology. Of the neck options used, 205 (44%) had a head center identical to that of a nonmodular M/L Taper stem. In another 56 cases (12%), all 3 reviewing surgeons agreed that the M/L Taper head center was so close to the Kinectiv head center as to be clinically indistinguishable. Of these 56 cases, 54 had a head center difference of less than 1 mm in length or offset; the other 2 had a 2-mm difference in offset.

Thus, a total of 261 stems (56%) had a standard M/L Taper option that offered an identical head center or one so close as to be clinically indistinguishable. Interestingly, in the group of 202 stems that did not have an identical head center and were not clinically indistinguishable, 132 (65%) of these modular stems were within 4 mm in length and 2 mm of offset of the closest Kinectiv head center. A verted neck was used in 12 cases (11 anteverted, 1 retroverted).

Nine of the 463 cases required revision surgery, 3 for recurrent instability. In 1 of these 3 cases, the acetabulum was revised for malposition, and the neck was converted from standard offset, +0 mm length (head center identical to nonmodular stem), to extended offset, +4 mm length (2 mm shorter with 1 mm less offset than closest nonmodular head center). The second case had complete deficiency of the abductor tendons and was converted to a constrained liner, though at the time of the THA a head center identical to that of the nonmodular stem was used. The third case was revised to convert a standard offset, +0 mm length, straight neck (head center identical to nonmodular stem), to extended offset, +4 mm length, anteverted neck (anteversion making this a unique head center position). Of the other 6 cases, 1 was treated for corrosion at the head–neck junction by changing the head from cobalt-chromium to ceramic (the junction was noted to be pristine), 1 underwent revision of the acetabular component for loosening, 2 femoral stems were revised for periprosthetic femur fracture, and 2 cases underwent 2-stage revision for late infection. There were no failures secondary to metallosis at the neck–stem junction and no modular breakages. The 3 cases of recurrent instability had no dislocation episodes after revision.

Discussion

PFNSM was developed to help more closely reconstruct patient anatomy. PFNSM allows for individualization of offset, length, and version—and thus for optimization of component interaction to avoid impingement and dislocation while promoting range of motion and normal gait.[21] These benefits must be judged in light of the disadvantages of proximal stem modularity, including corrosion and breakage of the modular neck.[14-18]

In the present study, conducted in a high-volume private practice setting, 44% of necks used in a proximally modular construct had a head center identical to that of a nonmodular alternative. In the opinion of the 3 authors (high-volume hip surgeons), an additional 12% of the modular stems had a head center so close to that of the nonmodular stem as to be clinically indistinguishable. In addition, 132 of the modular necks had a femoral head center within 4 mm in length and 2 mm of offset of the nonmodular stem. These findings call into question the theoretical benefits of regular use of this modular femoral stem for primary THA. Certainly there are extreme femoral neck–shaft angle cases in which the standard nonmodular stem may be inadequate and this proximal modu-

larity would be helpful, but our study showed such cases are relatively less frequent. We caution against routine use of this proximal modularity in primary THA and suggest restricting it to cases in which the standard stem offerings are unacceptable. These findings are not surprising given that the standard M/L Taper stem is based on a historically successful model with neck angle and length options designed to meet the goals of restoring length, offset, range of motion, and stability. We would expect that a well-designed stem will meet these goals in the majority of cases.

Of our 463 cases with the modular neck, 9 required revision surgery. Of these 9 revisions, 2 were for recurrent dislocation in which the modular neck was revised to one that enhanced stability, and there were no further dislocations. The ability to change the geometry of the proximal femur resulted in a stability solution that avoided revision of the entire femoral component, as might otherwise be required. One case of acetabular loosening and 1 case that required placement of a constrained liner were potentially benefited by the modular neck in that the surgeries may have been expedited by being able to remove the neck to ease exposure for placement of the acetabular components. The other 5 revisions—2 for periprosthetic femur fracture, 2 two-stage revisions for infection, and 1 femoral head exchange for metallosis at the head–neck junction—saw no benefit from the modularity in the revision setting.

This study had several limitations. First, as it was primarily an evaluation of use of a modular femoral system, there was no attempt to account for the fact that acetabular component orientation can affect stability and, thus, the perceived need for additional offset or changes in version. The habit of all 3 of the reviewing surgeons is to consider the position of the acetabular component and to reposition the component, if necessary, to achieve appropriate stability. Therefore, the need for the modularity may be even less than suggested by this study. In addition, the idea that (in 12 cases) no standard stem option would be acceptable because of the use of a verted neck ignores the possibility that cup repositioning could have obviated the need for additional version. Furthermore, use of a 36-mm head results in an additional 3.5 mm of offset in the polyethylene liner, and this study did not account for the option of increasing head size—and for the potential increase in stability from a larger head and the increased offset gained from the liner.

A second limitation is that a significant number of Kinectiv stems (132) had a head center within 4 mm in length and 2 mm of offset of the nearest M/L Taper stem. We carefully template every primary THA to determine the plan that will optimize component size and position and restore length and offset. More options for achieving these goals are available when templating with the intention of using the Kinectiv modular neck. The neck cut and position of the stem proximally or distally in the proximal femur may not need to be so exact, as the additional options may be able to accommodate minor inaccuracies. Thus, the reported percentage of clinically indistinguishable head centers (12%) may underestimate the actual number of modular stems that could have been replaced with a nonmodular stem.

Third, this study did not evaluate the effect of the modular junction on ease of irrigation and débridement with head/neck and polyethylene exchange in cases of infection, or on ease of head/neck and polyethylene exchange for revision. In addition, the study did not evaluate other cases of instability involving a nonmodular stem that otherwise could have been solved with simple revision of the head/neck combination, avoiding revision of the entire stem and/or the acetabular component. We reported revisions for infection and for instability, but comprehensive assessment and comparison were beyond the scope of this study. Certainly ease of revision of the head and neck is a factor that could favor use of the modularity.

Fourth, this was not a clinical outcome study comparing 2 different femoral stems. We sought only to determine how often a modular neck was chosen that resulted in a head center that would have been unavailable to the non-modular stem suggesting that the patient was receiving a reconstructive benefit in exchange for the modularity. However, 2 recent reports have noted no clinical benefit at 2-year follow-up with use of the modular neck compared with the nonmodular stem.[22,23]

Though the M/L Taper with Kinectiv technology has, thus far, performed well, PFNSM should be used with caution in light of recently reported failures at the neck–stem junction.[14,16-18] Our study results suggest that most (≥56%) of the modular stems used could have been reconstructed as acceptably with a nonmodular stem, and therefore a reconstructive benefit was not realized in trade for the potential risks of proximal modularity. Only 2 of the 9 revision cases saw a clear advantage in being able to change the modular neck geometry in the revision setting. Given the recently reported failures and the high-profile recall of a modular stem,[14] we recommend restricting the modular stem to cases that cannot be adequately reconstructed with the nonmodular option.

Dr. Carothers, Dr. Archibeck, and Dr. Tripuraneni are Surgeons, Center for Joint Replacement, New Mexico Orthopaedics, Albuquerque, New Mexico.

Address correspondence to: Joshua T. Carothers, MD, Center for Joint Replacement, New Mexico Orthopaedics, 201 Cedar SE, Suite 6600, Albuquerque, NM 87106 (tel, 505-724-4300; fax, 505-724-5161; email, carothersjt@nmortho.net).

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