Design Considerations for Modular Stems

By

Timothy McTighe, Dr. H.S. (hc)

Acknowledge: H.U. Cameron, D. Brazil, T. Donaldson, L. Keppler J. Keggi, E. McPherson, A. Turnbull, B. Vaughn and all the surgeons that have encourage and participated in clinical/surgical research with me since 1984

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Joint Implant Surgery & Research Foundation

Founded in 1971 by Prof. Charles O. Bechtol, M.D.
I attending my first hip course in Chicago in 1973 sponsored by JISRF
Remember the Goals of THA

Eliminate Pain
- New Bearing Surface

Restore Function
- Reproduce Hip Mechanics
  1. Femoral Offset
  2. Neck Length
  3. Combined Version Angle

Difficult to adjust with/monoblock stem
Challenge: Joint Stability takes precedent over desired leg length

Single biggest medical/legal problem in THA is leg length Cameron

- Offset is limited with monoblock designs
- Modularity means versatility
Two Remaining Significant Problems in THA

#1 Dislocation
- Reports from 1-8%
- Higher in Posterior Approach
- Higher in Sm. Dia. Heads 22mm
- Higher in Revisions >20%

#2 Wear Debris/Lysis

Proximal femoral cavity from polyethylene granuloma 4 yrs postop
Dr. Amstutz
“Despite a number of improvements in femoral Neck geometry and increasing femoral head sizes up to 36 mm, dislocation continues to be a significant problem after THA”
CURRENT DISLOCATION COSTS

Estimating a conservative 2% dislocation rate, there would be a corresponding 6,000 dislocated hips each year.

- Non-operatively treated - 4,500 (75%) - $6,000
  Cost: relocation, brace, x-rays, rehabilitation

- Operatively treated - 1,500 (25%) - $25,000
  Cost: operation, brace, and rehabilitation

$6,000 x 4,500 = $27 million
$25,000 x 1,500 = $37.5 million

Total cost of dislocations per year in the United States. $64.5 million

“Wright Medical Web Site”
Modularity or multi-piece stems are becoming commonplace in THA with virtually all implant companies offering one version or another.

A sift from fit & fill to restoration of biomechanics
Modularity is not new
Proximal Modularity

Designed in the 1970’s by Bousquet et al.
First reference: 
39 Annual meeting of the CAOA 1983 
Modular junctions are not equal in design, function or technique

- Many modular designs have come and gone
- Will clinical outcomes justify the cost
Examples of modular junction failures
Being Fair

Monoblock stems also fail

All devices are subject to failure!
Modular junctions are not equal

Historical Torsional Loads have been underestimated

Intrinsic stability of tapers

95 ft-lbs/128.8 Nm

Extrinsic stability of composite design

1984

Reported stem/sleeve
Slippage in undersized stems

Old design
Concern

- Patient Related Activities and Biomechanical loads!

- 12-23 Nm max.
- 30-40Nm
- 30 Nm of torque needed to loosen an implant

Torsional Loads
Femoral Component Failure is a concern both clinically and legally.

The more modular sites the more possible problems.
The Stability™ & Intrinsic™ designs were influenced by European Concepts
Target Restoration

By: Tom Tkach, MD; Warren Low, MD; George B. Cipolletti, MS; Timothy McTighe, Dr. H.S. (hc)

- Instability - What should be done? Trail reduction demonstrates joint instability with slight increased leg length.

- Modular Heads allow length adjustment, unfortunately increase head length increases leg length.

- Big Heads! Theoretically, a bigger head is more stable... At the extremes of motion when the neck impinges in this case, intrinsic stability is unchanged (Head center stays the same).

- Biomechanical Solution Modular Neck! Add offset for joint stability reduce length for proper gait.

• This proximal modular design permits the independent selection of offset, version and leg length.
Head Center Data

2,000 Proximal modular stems implanted 2001-2005
AAOS 2006 Scientific Exhibit
957 THA’s Performed (2001-2005)
842 Primary/115 Revisions
Data collected on 800

- Center of bubble /head location
- Dia. Indication of frequency
- Several values are listed

Version Position

Combined Version should be the focus

Typical 15 - 40° more ROM with neck anteverted.

Neutral neck position. 15° anteversion.

Aneterved neck used 18 times in the first 200 cases.
Femoral Offset

(fatigue concern - all devices are subject to failure)

- Offset (reduces) hip reaction forces
- Increased offset increases torsional loads
- Increased offset increases bending moment of implants
Femoral Offset Concerns

One way of reducing implant concerns is by Design. Broad surface contact.
Another way by design
Save the neck

- The varus-turning moment increases by a factor of 4 when the neck is resected.

Topic For Debate
Why Resect The Neck?
M.A. R. Freeman JBJS 1984
Save the Architecture
With the neck resected this force generates significant torsional moment on the device which is resisted by shear at the stem/bone interface.
Which do you think has better torsional stability?

Curved trapezoid shape with/T back
Persevering what we can by design & technique
FEA Modeling

von Mises Stress
Peak Gait

Intact  Short Stem/MSA™  Long Stem/Porous Coated

0 MPa  5 MPa  10 MPa
“Neck Sparing Total Hip Arthroplasty
Lessons Learned”

By: T. McTighe¹,
I. Woodgate², A. van der Rijt³, A. Turnbull², J. Harrison², D. Brazil²
L. Keppler², J. Keggi², K.J. Keggi², R. Kennon², S.D. Stulberg², L.E. Rubin²

Novel: proximal conical flair loads the medial

Posterior approach    Anterior approach
38 yr old female
auto / injured at 16 in 1987
comminuted acetabular fx & femoral shaft fx.
Dr. Charles Bryant
trial rasp in place

Anterior Approach
The need and use of modularity example of surgical day for Lou Keppler, MD, Cleveland, Ohio
Modular Designs
Small Incisions

- Works for all incisions even small anterior “Keggi” approach
By L. Keppler, MD and T. McTighe, Dr. H.S. (hc)

3 Case Report on Proximal Modularity

Was effective in all three cases!
Dr. Russ Nevins
18 yr old fusion takedown
Patient is happy and doing well @ 12 months
There is a role for modularity!

The Role of Modularity in Primary THA - Is There One?

By Louis Keppler, M.D.*, Hugh U. Cameron, MB, ChB, FRCS†, Timothy McTighe, Ph.D. (hc)²

Introduction

Modularity or multi-piece stems are becoming commonplace in hip revision surgery⁴,⁶,⁷ with virtually all implant companies offering one version or another. The role of modularity would therefore seem to be firmly established for revision, but what of primary cases?³,⁴

This study is a follow-up to previous work with a further ten years of cases reviewed. The real question we face does the benefit of modularity pay higher dividends than the potential risk factors. We believe this review will provide guidance for others surgeons to aid in their decision making process.

For almost two decades the two senior authors have been using a proximally modular stem in primary cases. The S-ROM stem has...
Modularity offers significant benefits but you need to know its limits!

- Improved modular designs appears to have addressed many of these concerns but do we know its limits?

Second Generation “Dual press™”

design 216 ft-lbs./292.8 Nm
Pin larger and stronger
Discussion

- Restoration of normal joint mechanics on a consistent basis is improved with modular designs.
- Provides for intra-operative fine tuning of biomechanics without disruption of implant bone interface.
- Provides for increased exposure to socket in revisions.
- Provides intra-operative options in case of dislocations.
- Significant number of small (10mm/11.5mm) stems required > 45mm offsets.
Conclusion

- The head center data suggest reconstruction benefits from the availability of many head centers for each stem size.
- Proximal modular design allows for restoration of proper soft tissue tension and joint biomechanics without disruption of implant interfaces.
- New tissue sparing implant designs are emerging and hold significant promise.

We are encouraged and remain enthusiastic about the features and benefits of proximal modularity.