Design Consideration for Modular Stems

by
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RLO*: Charleston
Joint Replacement Surgery 2010, May 6-7, 2010
Charleston Place Hotel Charleston, South Carolina
* Real Life Orthopaedics
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 w/ monoblock stem
Challenge: Joint Stability takes precedent over desired leg length
#1 Dislocation

- Reports from 1-8%
- Higher in Posterior Approach
- Higher in Sm. Dia. Heads 22mm
- Higher in Revisions >20%
Big Heads
Navigation
Constrained Sockets
Increased Offset stems
Hard on Hard Bearings

Dr. Amstutz “Despite a number of improvements in femoral stem neck geometry and increasing femoral head sizes up to 36mm, 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 of Femoral Components

- Modularity or multi-piece stems are becoming commonplace in THA with virtually all implant companies offering one version or another.
Modularity is not new
Proximal Modularity

Designed in the 1970’s by Bousquet et al.
First reference:
39 Annual meeting of the CAOA 1983
The Stability™ & Intrinsic™ designs were influenced by European Concepts.
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

Typical 15 - 40° more ROM with neck anteverted.

Neutral neck position.

15° anteversion.

Anteverted neck used 18 times in the first 200 cases.
Modular junctions are not equal in design, function and technique

- Many modular designs have come and gone
- Will clinical outcomes justify the cost
Concern

Patient Related Activities and Biomechanical loads!

Torsional Loads
12-23 Nm max.

30 Nm of torque needed to loosen an implant
Femoral Component Failure is a Concern
Both clinical and Medical/Legal
The more modular sites the more possible problems
Femoral Offset

(fatigue concern - all devices are subject to failure)

- Offset effects (reduces) hip reaction forces
- Increased offset increases torsional loads
- Increased offset increases bending moment of implants
Modular junctions are not equal

Intrinsic stability of tapers

Extrinsic stability of composite design
Examples
of modular junction failures
Being Fair
Monoblock stems also fail

All devices are subject to failure!
Femoral Offset Concerns

One way of reducing implant concerns is by Design. Broad surface contact.
Another way is 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
Torsional Resistance

A/P directed resultant force

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?
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!
18 yr old fusion takedown
Technique
Patient is happy and doing well @ 6 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)*

Introduction
Modularity or multi-piece stems are becoming commonplace in hip revision surgery 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?1

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 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

The Role of Modularity in THR
Modular means that the stem has 2 or more parts which can be joined. Does that mean any stem with a modular head is a modular stem? Not in today’s definition. This exhibit is limited to the femoral side and includes two or more modular parts.7

Modular Stem History
Modular stems have a long history staring with McBride in 1948 that utilized a threaded femoral component publishing his first account in JBJS in 1952. This was followed in 1978 by Bousquet and Bornand with the development of a proximal modular stem that featured a proximal body that
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.