REVISING THE DEFICIENT PROXIMAL FEMUR

by

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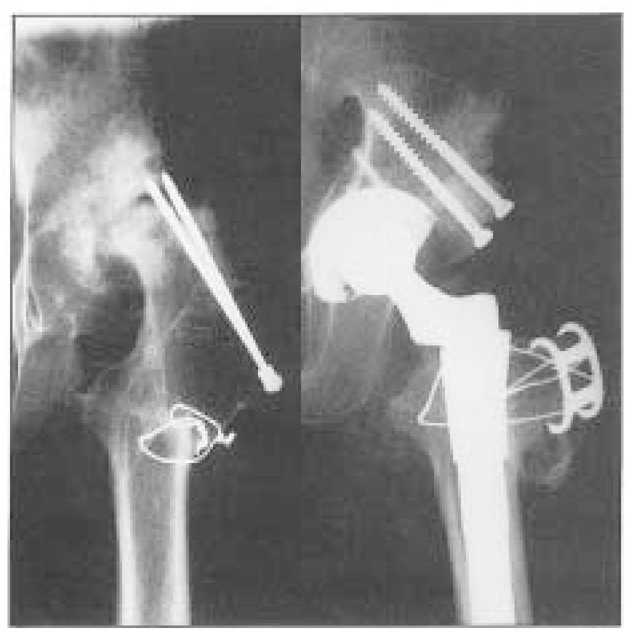
INTRODUCTION

In the last few years, as we encounter more difficult and unusual situations, revision total hip arthroplasty has become increasingly more sophisticated stimulating the use of autografts, allografts, modular and custom implants. However, the goals of revision surgery remain the same as primary arthroplasty: reduction of pain, equalization of leg length, restoration of movement, creation of joint and implant stability.

Defining and classifying femoral defects has been done by a number of authors. [1,4,5,9,13] However, interpretation of these classifications can be confusing and frustrating due to the need of a reference chart. This exhibit will use descriptive terms (modified AAOS classification) to define the deficient proximal femur. In addition, guidelines will be given as to implant selection for each classification category.

The most common cause of proximal bone loss is due to osteolysis. Although the specific cause of lysis is not known, it has been attributed to a variety of factors, including motion of the implant, foreign-body reaction to particulate debris and hypersensitivity to metal.[3,6,7,10]

While revision surgery is technically demanding, this exhibit will demonstrate that it is possible to achieve short term success in treating the deficient proximal femur with a proximal modular cementless stem system.



METHODS AND MATERIALS

Cases were retrospectively reviewed from three different hospitals and six different surgeons in order to evaluate the use of a proximal modular femoral stem system in total hip arthroplasties with bone deficiencies of the proximal femur. Only patients with a segmental proximal femoral bone deficiency and a minimum one year follow-up were included in the study.

Segmental femoral deficiencies were defined as:

Level A	Slight (bone loss above the top of lesser trochanter)
Level B	Moderate (bone loss through the base of lesser trochanter)
Level C	Severe (bone loss below lesser trochanter to the isthmus)
Level D	Extreme (bone loss below the isthmus)

Hospital and office records were reviewed to evaluate individual results, technical errors, complications and failures. Preoperative, immediate and serial post operative radiographs were also reviewed to define femoral bone stock deficiencies, types of bone graft and radiographic evidence of subsidence and loosening.

Patient Profile.

133 Patients: 68 Males/65 Females
Age: 25 - 84 (average 65)
Follow-up: I - 6 years (average 3 years)

Diagnoses	*# Hips*
Aseptic Loosening	102
Failed Inter Trochanteric Fracture	6
Congenital Dislocated Hip	6
Girdlestone Conversion	9
Failed Osteotomy	10
Total	133

Acetabular Components	
Original cemented left	13
Original threaded left	4
Bipolar	37
Threaded 19	
Fixed, Ingrowth 60	
Total	133

S-ROM™ Components

Proximal Sleeve: ZTT-117 SPA-16
Neck Type: Calcar replacement - 82; Standard - 51
Stem Lengths: Primary (< 200m) - 57; Revision (>200mm) - 76

Segmental Femoral Deficiencies	
Level A - Slight 43	
Level B - Moderate	43
Level C - Severe	44
Level D - Extreme	3
Total	133

Structural Bone Grafts	
Onlay	18
Proximal Replacement	5
Inlay	1
Total	24

IMPLANT SELECTION

Immediate implant stability is an absolute requirement in cementless revision arthroplasty.[14] In order to achieve stability, metaphyseal and diaphyseal fill is required. It has been previously reported that a constant proportional relationship is not present between the shape and size of the metaphysis and diaphysis.[11] In addition the revision situation results in alterations in the normal bony architecture, making fit and fill more difficult to achieve.

The S-ROM™ Total Hip System allows for intraoperative options by design of a modular metaphyseal sleeve that is available in a variety of sizes and shapes.[2] This proximal sleeve is attached to the stem by means of a taper lock.

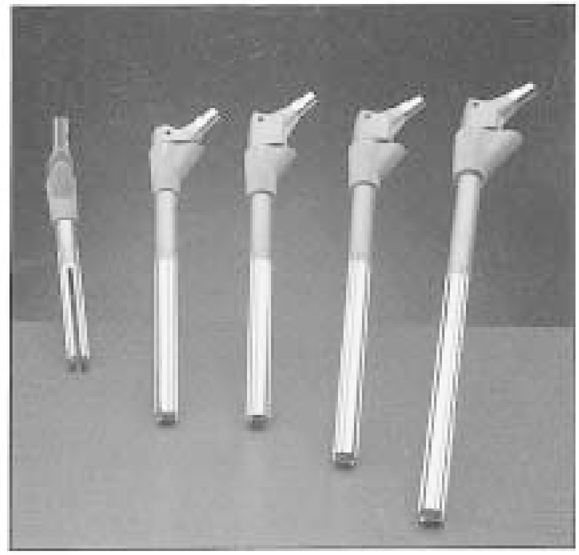
FLUTED STEMS

The stem has three distinguishing dimensions:

1.) Stem Diameter (proximal and distal)
2.) Stem Length
3.) Neck Length

All of the stems have a proximal taper, a fluted distal diameter, and a taper lock head fitting. A proximal taper permits the use of a variety of self-locking proximal sleeves that help customize the fit in the deficient proximal femur. In addition, all stems have a coronal distal slot. This reduces bending stiffness by approximately 80%.

With moderate cavitary and segmental bone damage it is difficult to achieve rotational stability of the implant. In this situation some authors have previously recommended distal fixation.[5] It is our opinion that distal stability is preferable over distal fixation. This can be achieved by fluting the distal end of the stem. Whiteside[12] and Koeneman[8] have shown that fluting offers more initial stability in torsion as compared to a fully porous coated stem.

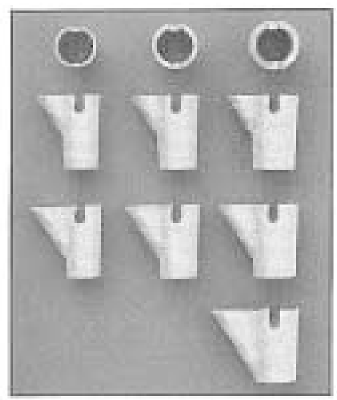


Array of stem selections

PROXIMAL SLEEVES

The variety of sizes and styles of proximal sleeves allows for a intra-operative custom-type fit for each patient. This gives the advantage of adapting the device to the geometry of the patient reducing the need for allograft, autograft and custom devices.

These have been described in detail in a previous scientific exhibit.[3]



Array of sleeve selections

ASSESSMENT OF BONE STOCK

(Modified AAOS Classification)

I. Cavitary Expansion: Slight, Moderate, Severe
   A.) Metaphyseal
   B.) Diaphyseal
   Definition: Loss of cancellous and/or cortical bone from within.

II. Segmental: combination with cavitary
   A.) Slight (bone loss above the top of lesser trochanter)
   B.) Moderate (bone loss through the base of lesser trochanter)
   C.) Severe (bone loss below lesser trochanter to the isthmus)
   D.) Extreme (bone loss below the isthmus)

III. Cortical Deficiency
   Definition: Any fracture, perforation or loss of cortical substance

IV. Malalignment
   A.) Version abnormalities
   Definition: Too much anteversion or retroversion.
   B.) Angular deformity
   Definition: Diaphyseal angle or bow restricts the insertion of the femoral stem.

TREATMENT GUIDELINES

Implant Guidelines

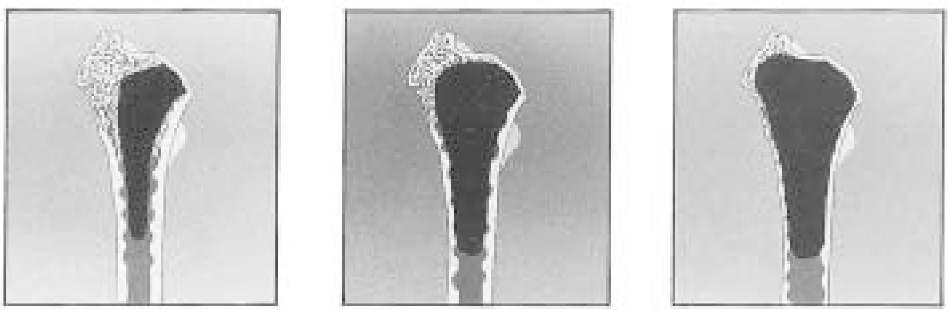
1. CAVITARY EXPANSION: *A) Metaphyseal B.) Diaphyseal*

Slight *Moderate* *Severe*

METAPHYSEAL EXPANSION

Treatment:

Slight - Standard stem, B, D or F cone with small or large triangle.
Moderate - Standard or long stem, D or F cone with large triangle.
Severe - Standard or long stem, F cone or upsize cone by use of mm diameter increasing sleeve. Possible inlay graft with cemented sleeve and press fit cementless stem. Possible onlay graft for cortical reinforcement.

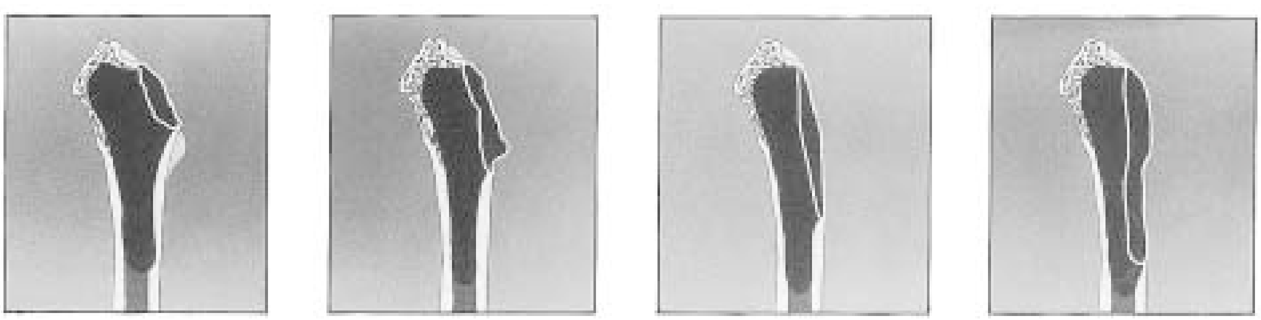


Slight *Moderate* *Severe*

DIAPHYSEAL EXPANSION

Treatment:

Slight - Large diameter stem. Standard or long depending on segmental loss.
Moderate - Larger diameter stem. Standard, long or extra-long depending on segmental loss.
Severe - Largest possible diameter stem. Long, extra-long, or extra, extra-long depending on segmental loss. Possible onlay cortical graft for reinforcement. Possible intramedullary graft.

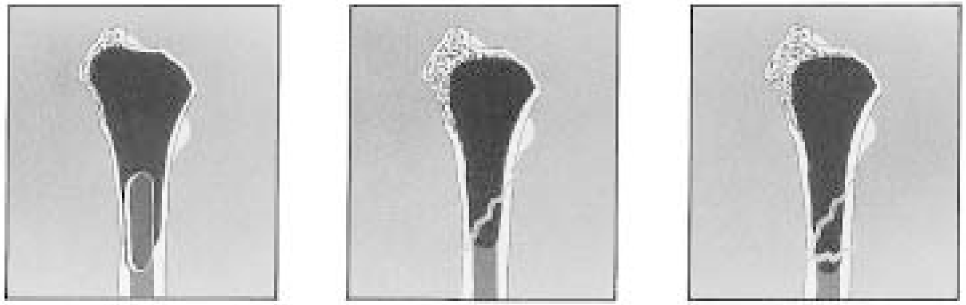


Slight *Moderate* *Severe* *Extreme*

II. SEGMENTAL

Treatment:

Slight - Standard stem, B, D or F cone with small or long triangle.
Moderate - Calcar long stem. Possible 42 neck, long stem, Possible+12mm head.
Severe - Extra-long or extra, extra-long stem with segmental sleeve or allograft.
Extreme- Extra, extra-long stem modified with locking screws segmental sleeve or allograft.

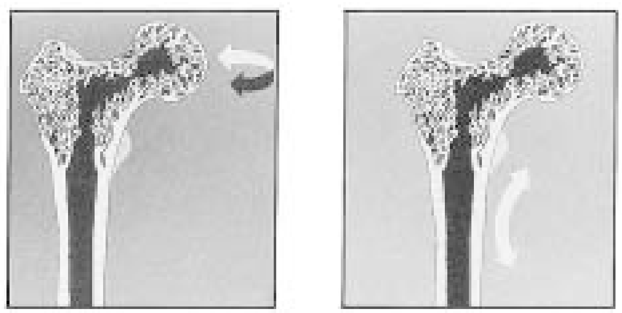


Window *Crack* *Fracture*

III. CORTICAL DEFICIENCY

Treatment:

Windows less 113 canal diameter - Stem bypass by 21/2 canal diameters with or without graft.
Windows greater than 113 canal diameter - Stem bypass by 21/2 canal diameters with onlay bone graft.
Crack - Cerclage and possible onlay grafts.
Fracture - Stem bypass at least 21/2 canal diameters with cerclage and possible cortical onlay grafts.



Version Abnormalities *Angular Deformity*

IV. MALALIGNMENT

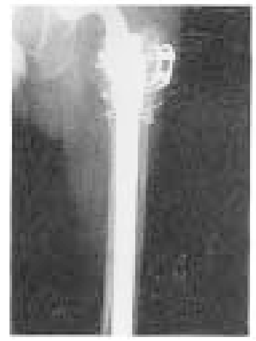
Treatment:

Version abnormalities - Index sleeve into position of structural support. Index stem into position of function.
Angular deformities - Osteotomize through deformity stem bypass by greater than 21/2 canal diameters.

CLINICAL EXAMPLES

Moderate Cavitary Expansion Metaphysis

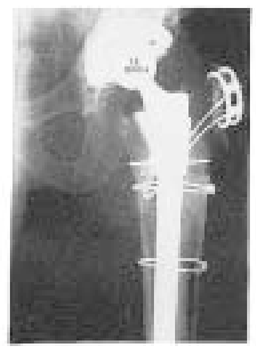
Pre-op



Post-Op

Severe Cavitary Expansion Metaphysis

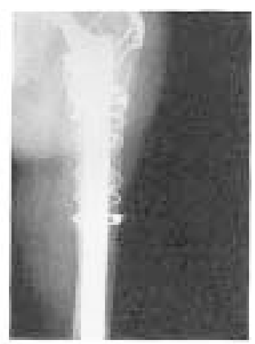
Pre-op



Post-Op

Severe Cavitary Expansion Diaphysis

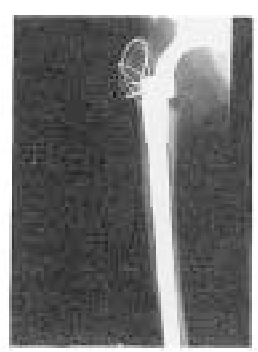
Pre-op



Post-Op

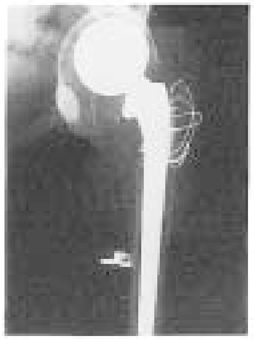
Segmental Slight

Pre-op



Post-Op

Segmental Moderate

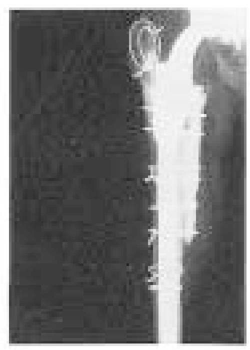


Pre-Op

Post-Op

Segmental Severe

Pre-op



Post-Op

Segmental Extreme

Pre-op

Post-Op

CORTICAL DEFICIENCY
Crack (Cement)

Pre-op

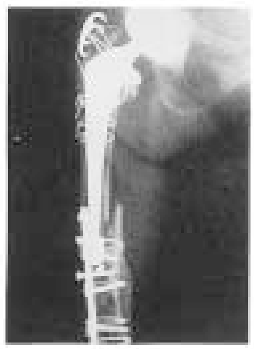
Post-Op

Crack (Stem Perforation)

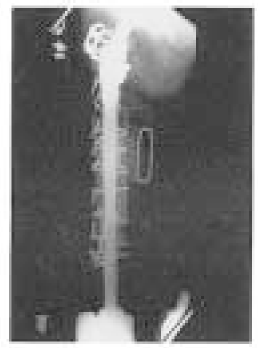
Pre-op

Post-Op

Fracture (Discontinuity)



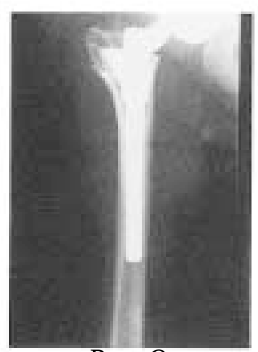
Pre-op



Post-Op

MALALIGNMENT
Version Abnormalities

Pre-op



Post-Op

Angular Abnormalities

Pre-op

Post-Op

TECHNIQUE

Pre-op Assessment

1. X-ray Review
   AP and Lateral view entire femur
   Look for cavitary expansion
   Look for segmental loss
   Look for cortical infraction
   Look for bow malalignment

2. Reference Treatment Guidelines

3. Order necessary inventory (special instruments, implant, grafts)

4. Plan operative staging Example. While removing bone cement, preparation of graft material can take place saving valuable operative time and blood loss.

   If adequate help is not available, possible consideration of graft preparation prior to putting patient under anesthesia should be considered.

5. Surgical Technique
   In order to manage the deficient proximal femur, an extensive exposure of the hip is necessary. In general, the lateral shaft of the femur may be exposed to facilitate orientation to the canal, to address cortical perforations and to perform osteotomies when needed.

   This exhibit will not discuss implant or cement removal. Following removal of old implant, cement and assessing defects, femoral preparation is carried out.

   Prior to preparation, consideration should be given to prophylactic wires or cables. If a bowed stem is being used, flexible reamers must be used for canal preparation. It is critical to review pre-operative lateral x-ray to determine if the angle of the bowed implant will match the patients bow. Over reaming the major diameter by I or 2 mm is often necessary. If the patients bow angle is greater than that of the implant, an osteotomy should be done through the deformity, and a long straight or bowed stem can be used.

The fluted distal stem has a minor and a major stem diameter. The flute depth is approximately 0.5. mm. Distal stem diameter is determined by diaphyseal reaming, similar in technique to reaming for an intramedullary nail.

The anterior bow of the femur is encountered at approximately 200 mm. Straight distal reamers may perforate the anterior femur. In most cases requiring a long stem a bowed stem is preferred.

The depth of canal reaming should correspond to stem length.

When using a straight stem in hard cortical bone, it might be necessary to ream up 0.5 mm.

The proximal stem diameter establishes the proximal conical reamer series required to prepare the cone of the sleeve.

There are three conical sizes for each stem B, D and F. The differential of each letter/cone size is 2 mm. The conical reamers should be used in a progressive sequence.

The depth of the conical reamer is determined by the bony segmental loss. Example, if bone is missing down to the level of lesser trochanter then the conical reamer is taken to this level. The final conical reamer corresponds to the final cone implant size.

Triangle preparation is done with the calcar cutter. Often this instrument is not needed in revision situations. However, if this instrument is to be used, align the calcar miller for maximum bony containment of the triangle of the sleeve. The alignment of the calcar miller does not determine the final anteversion of the femoral stem. After milling, trial sleeves are used to determine final triangle size. A trial stem can be inserted to determine final head/neck version and head/neck length. A detailed surgical technique on A the instruments has been published.’

RESULTS

Harris Hip Rating:

Pre-op: 13-77 (average 45)
Post-op: 65 to 100 (average 85)

		Patients	*%*
Excellent		51	38
Good		58	44
	Subtotal	109	82%
Fair		17	13
Poor		7	5
	Total	133	100%

Thigh Pain:

		Patients	*%*
None		122	92
Slight		6	5
Moderate		4	2
Severe		1	1
	Total	133	100%

Definition of Pain Score:

None - Self explanatory
Slight - No pain medicine and does not affect activity
Moderate - Analgesic and does affect activity if overdone
Severe - Analgesic and requires walking aid

Complications:

Femoral Aseptic Loosening: 2/133

Femoral Components Revised: (For sepsis reactivation) 2/133

Femoral Components Pending Revision: 1/133

Death - 2 days post-op	1
CXA (recovered)	1
Myositis occificans (Brooker III or IV)	1
Femoral nerve palsy (recovered)	1

Fractures:

Location	*Rx*	
Greater Trochanter	Screws & Wires	2
Proximal	Wires	18
Proximal	Onlay & Wires	4
Distal	Onlay & Wires	1
Distal	Traction	1
	Total	26

Stem Perforations	6
*Subsidence	5
Dislocations	6
Infections (superficial)	1
Infections (reactivation)	2

*Subsidence of 2 to 5 mm; all 5 radiographically stable with Harris scores > 90.

DISCUSSION AND CONCLUSION

Revising the deficient proximal femur presents a major challenge to the revision hip surgeon and the implant manufacturer. Clinical success is dependent on careful preoperative planning, avoidance of major complications, bone preservation and/or augmentation, secure implant fixation and appropriate soft tissue balancing to produce a reliable and stable articulation.

Fractures and perforations remain the most frequent complications associated with complex femoral revision arthroplasty. Of our 26 fractures, approximately 40% occurred prior to final implant insertion. Most of these fractures (20 of 26) involved the deficient proximal femur, were simply treated by cerclage wiring, and did not affect the rehabilitation or clinical outcome of the patient. Fractures and perforations can be minimized by careful attention to the following principles.

- preoperative x-ray assessment of bone deformities and deficiencies
- adequate exposure of the deficient femur
- prophylactic cerclage wiring
- complete removal of endosteal ridges (bone and cement)
- osteotomy or bowed stems for angular deformities
- intra-operative x-ray evaluation

Dislocations following revision total hip arthroplasties range from 2 to 25%. We found the following principles to lower rates of dislocations:

- assessment of intra-operative instabilities with trial components
- restoration of leg lengths and soft tissue tensions
- proper alignment of components
- post operative bracing and casting for select patients with soft tissue deficiencies
- patient education concerning “safe limits” of motion for their reconstruction

Cementless application of the S-ROM™ Total Hip Porous coated devices are limited by U.S. Federal law to investigation use.

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