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The Reconstructive Review (ISSN 2331-2262 print, ISSN 2331-2270 online) will be published four times a year by the Joint Implant Surgery & Research Foundation, 46 Chagrin Plaza #117, Chagrin Falls, Ohio 44023.

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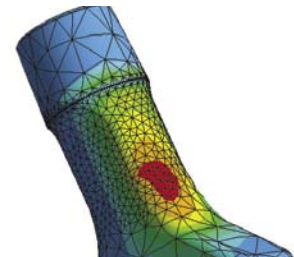
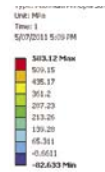


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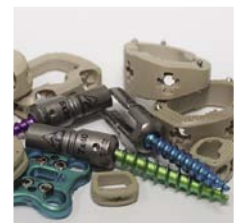
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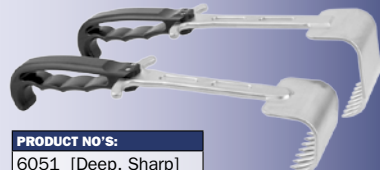
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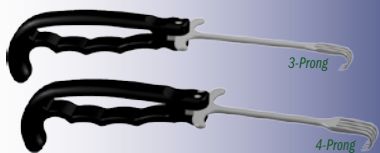
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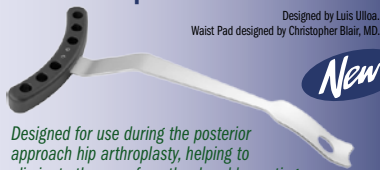
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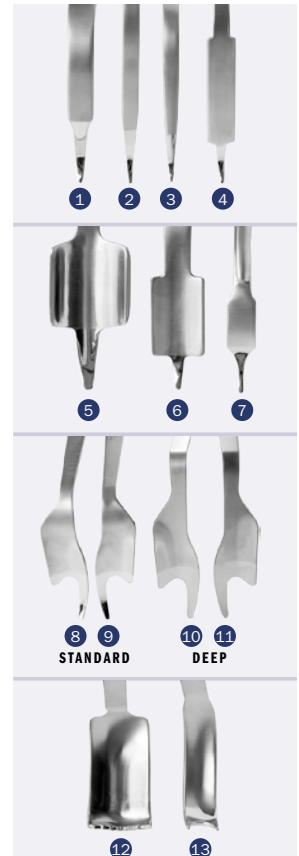
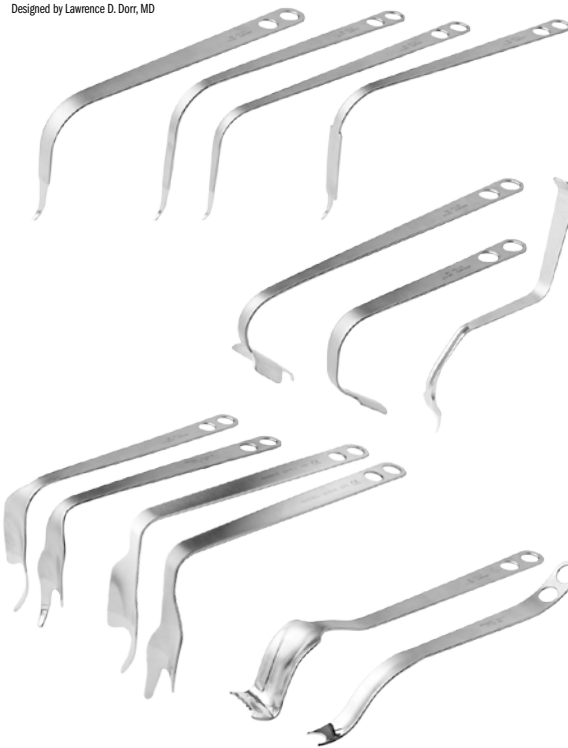
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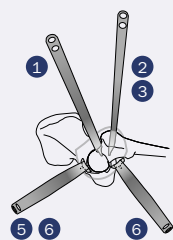


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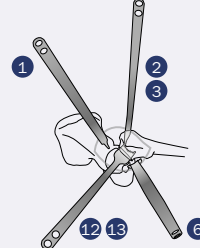
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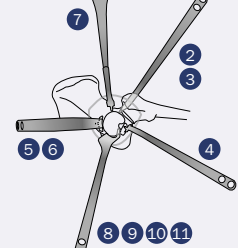
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Elevated Lip Liner Positions Improving Stability in Total Hip Arthroplasty – An Experimental Study

Qurashi S¹, Parr W², Jang B³, Walsh W²

Abstract

Background: The use of elevated lip polyethylene liners with the acetabular component is relatively common in Total Hip Arthroplasty (THA). Elevated lip liners increase stability of the THA by increasing the jump distance in one direction. However, the elevated lip, conversely, also reduces the primary arc in the opposite direction and leads to early impingement of the neck on the elevated lip, potentially causing instability.

The aim of the present study is to determine the total range of motion of the femoral head component within the acetabular component with the elevated lip liner in different orientations within the acetabular cup.

Methods: We introduce a novel experimental (ex-vivo) framework for studying the effects lip liner orientation on the range of motion of the femoral component. For constant acetabular cup orientation, the elevated lip liner was positioned superiorly and inferiorly. The femoral component range of motion in the coronal, sagittal and axial plane was measured. To avoid any confounding influences of out of plane motion, the femoral component was constrained to move in the tested plane.

Results: This experimental set up introduces a rigorous framework in which to test the effects of elevated lip liner orientations on the range of motion of the femoral head component in abduction, adduction, flexion, extension and rotation. The movements of this experimental set-up are directly informative of patient's maximum potential post-operative range of motion. Initial results show that an in-

ferior placement of the elevated lip increases the effective superior lateral range of motion (abduction) for the femoral component, whilst the anatomy of the patient (i.e. their other leg) prevents the point of femoral component – acetabular lip impingement being reached (in adduction).

Background

The demands of the patient receiving a modern total hip replacement are ever increasing due to younger and more active patients being operated on. Dislocation continues to be a common complication in total hip arthroplasty (THA). According to the Australian Orthopaedic Association's National Joint Replacement Registry (AOA NJRR), the 14 year cumulative percent revision for primary THA is 9.5% of which 24.2% is due to dislocation [2]. Thus, new implant designs, bearing surfaces and the use of muscle sparing surgical approaches claiming increased stability without standard hip precautions are being utilised [3, 4].

Studies on normal physiologic hip Range Of Motion (ROM) have shown varied results with hip flexion and extension ranges of up to 150 degrees, as well as hip abduction and adduction ranges of up to 80 degrees [5-6]. It is also accepted that reaching a minimum ROM benchmark is required to achieve a good functional outcome post THA

Keywords: total hip, arthroplasty, dislocation, stability

Level of Evidence: AAOS Therapeutic Level V

Educational Value & Significance: JISRF Level C

[5]. However, this quest for a greater functional ROM in a THA also has to be balanced with stability so as to avoid a dislocation and its consequences. To such an extent, the use of an elevated-rim acetabular liner is widely accepted in THA to improve stability [7-8]. It was first used by Charnley to decrease posterior dislocations of the femoral head component [9]. Improved stability was first shown by Cobb et al [10] in a retrospective study of elevated-rim liners in THA.

The factors affecting stability from a component position and design perspective are dictated by two key concepts, 'Primary arc' and the 'Jump distance' [11-12]. The total movement of a prosthetic head inside a Polyethylene liner until the point of impingement is known as the 'Primary arc'. The further movement from that point until the point of dislocation is known as the 'Jump distance' (Figure 1).

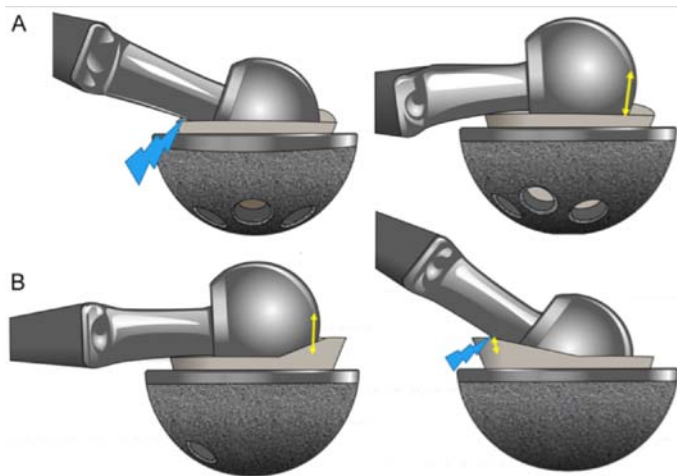


Figure 1 A) Primary arc and jump distance. B) Lip liner increases jump distance in one direction and decreases primary arc in opposite direction.

Any factor that increases the primary arc or jump distance should increase stability [11, 12]. Elevated-rim liners improve stability by increasing the jump distance in one direction. However, they have been shown to reduce the primary arc of motion in the opposite direction and lead to impingement (Figure 1b). Impingement between the rim of acetabular component and the neck of the femoral stem is a known cause for dislocation [13]. This occurs by a lever effect of the impingement forcing the femoral head over the acetabular rim, which causes the dislocation. The point of impingement will vary according to the position of the elevated rim in the acetabular shell; impingement will occur more or less in a certain direction depending on the specific plane of movement and the position of the elevated rim.

Shon et al [14] showed in their retrospective retrieval study that the worst combination for impingement, with 92% prevalence, was the use of an elevated-rim acetabular

liner with a femoral neck with extended offset and a flange. They showed that the most common site for impingement was posterior, however, impingement could occur at any location from excessive joint motion. Currently, the postero-superior positioning of the lip liner has been shown to provide additional stability [15], however, a common direction of dislocation is posterior when the hip is flexed and internally rotated [10,16], i.e., posteroinferiorly. Anterior direction of dislocation has also been reported. Yamaguchi et al reported impingement in cases with excessive cup anteversion with posterior positioning of an elevated-rim liner [17].

As well as liner rim positioning, there are several other factors that can increase the incidence of impingement including: acetabular component diameter size; femoral head size; acetabular component positioning and active ROM.

Given the paucity of information in the literature on the effect of elevated-rim liner position and its relation to stability and impingement, the aim of the present study was to investigate impingement points and optimal elevated-rim liner positions. To minimise errors that could be associated with physical testing of ROM in different planes with different rim orientations, we used a validated computational modelling experimental design. Our null hypothesis was that an inferior placement of the lip will increase ROM without any clinically relevant consequent reduction in primary arc in the opposite direction.

Materials and Methods

A size 1 short offset stem (Profemur L Classic, MicroPort Orthopedics Inc.), 32mm (0) head (Lineage femoral head, MicroPort Orthopedics Inc.), 50mm acetabular component (Dynasty PC Shell, MicroPort Orthopedics Inc.) with a 15 degree lip polyethylene liner (MicroPort Orthopedics Inc., Arlington, TN) were Computer Aided Design (CAD) reverse engineered from the physical parts (tolerance 0.1mm). Collision detection was used to define the impingement limits to the ROM of the femoral stem in the liner part of the CAD model (Figure 2a). The femoral stem was rotated around the centre point of rotation as calculated from the head component [18, 19]. The liner orientation was varied and the differences in in-plane ROM recorded.

To validate that the CAD model was accurate in predicting differences in ROM caused by different liner rim positioning, the ROM of the physical construct was measured. This was done by embedding the acetabular cup component in a block of foam so that the femoral component moved along the superior surface of the foam block. This constrains the motion of the femoral component to

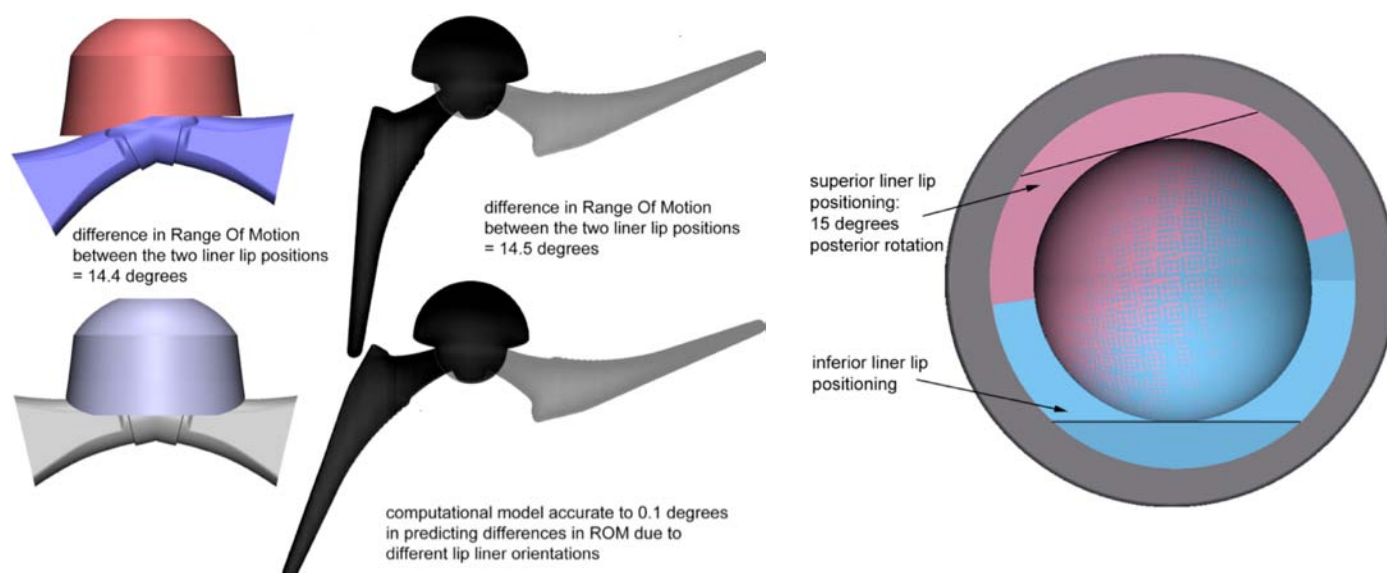


Figure 2a. (Image on left) Difference in range of motion between the two lipped liner positions.

Figure 2b. (Image on right) Positions of lip liner tested in the present study.

Figure 2a. Radiographic validation of the computational femoral stem and liner models. Left hand side shows the computational models of the liner and femoral neck component, right hand side shows (inverted) x-ray images of the femoral component (head and entire femoral stem) and the acetabular component (acetabular cup and liner). The images show that with the difference in range of motion of the femoral component between the two lip liner positions before impinging is 14.5 degrees.

occur within-plane. The set up was mimicked as best as possible in the CAD model (Figure 2a). Due to differences between the CAD and actual model's geometry and set up, the total ROM for the different liner rim positions varied between the CAD and actual parts. The difference in the ROM for the two liner rim positions, which is the focus of the present study, were highly similar (14.4 degrees and 14.5 degrees for the CAD and actual models respectively), validating that the CAD model was suitable for testing the effect of different liner rim positioning on the ROM of the femoral component of a THA.

In Figure 2a, the liner is radio-translucent, therefore not visible in the x-ray images. The top images show the in-plane range of motion (ROM) of the femoral component with the lip of the liner orientated to the left (see top left image). The bottom image shows the ROM of the femoral component with the liner lip rotated 90 degrees clockwise compared to the top image. Total in plane ROM of the liner with the lip oriented to the left (top case) for the computational model was 153.4 degrees. For the x-ray model the total ROM was 133.2 degrees. Total in plane ROM of the liner with the lip oriented upwards (bottom case) for the computational model was 139 degrees. For the x-ray model the total range of motion was 118.7 degrees. The difference in the ROM between the computational models was 14.4 degrees. The difference in the ROM between the two x-rays was 14.5 degrees. The computational model is accu-

rate to approximately 0.1 degrees in predicting differences in ROM due to different lip liner orientations.

A CT scan of a hip from a 77 year old female was used to create a three-dimensional (3D) isosurface model of the hemipelvis and proximal femur (Figure 3a). The CT DICOM stack was reconstructed using Materialise MIMICS (vs 19.0) software according to methods detailed in Parr et al [20, 21].

The coordinate system for the remainder of the CAD modelling was set according to a 3D isosurface reconstruction of a hip (Figure 3a and Figure 3b). The model was located at x, y, z = 0, 0, 0 in the Global Coordinate System (GCS) at the centre point of rotation for the femoral head using Materialise 3Matic software (vs 11.0) (Figure 3a).

For the remainder (the non-validation part) of the CAD experiment the acetabular cup, liner and femoral components were placed in this same coordinate system (Figure 3b).

The acetabular component was positioned with 40 degrees of abduction and 30 degrees of anteversion as this is the ideal acetabular cup position suggested by Scheerlinck [22]. We also acknowledge that there is significant variability in this range and the formerly described Lewinnek 'safe zones' have since been shown to vary based on the dynamics of the patient as well as the pelvis position in the sagittal plane changes throughout different stance positions and functional activities [23, 24].

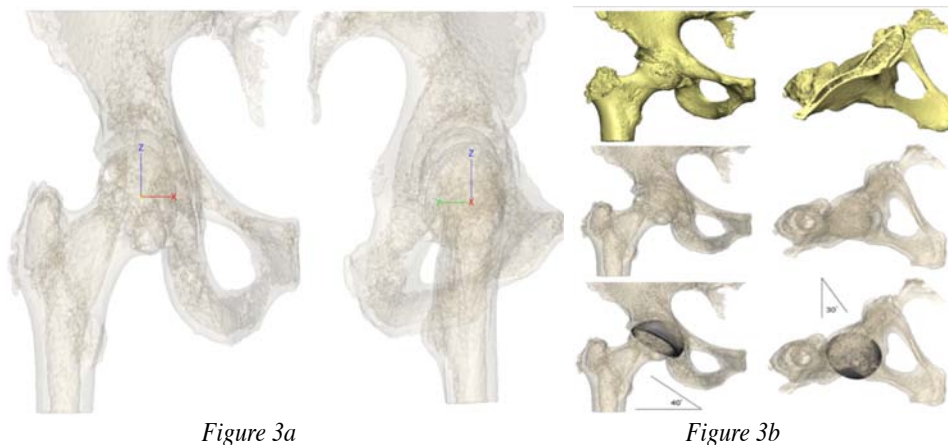


Figure 3a

Figure 3b

Figure 3a) the coordinate system for the model was set as the centre of rotation of the femoral head, with positive x being medial, positive y being posterior and positive z being superior.

Figure 3b) The 3D isosurface reconstruction of patient anatomy opaque (top), translucent (middle) showing some bone internal morphology and with the acetabular cup in place (bottom). The cup was oriented so as to be 40 degrees of inclination and 30 degrees of anteversion.

This position as well as the pelvis was fixed throughout the study with the femur rotating about the centre of rotation of the hip joint ($x,y,z = 0,0,0$ in the GCS). The liner within the fixed position acetabular cup was placed in two orientations: a superior orientation with the apex of the elevated rim rotated posteriorly by 15 degrees; and an inferior position (Figure 2b).

The femoral component of the CAD model was moved about the centre of rotation (COR) of the head component (which was set at the GCS $x,y,z = 0,0,0$, see above). The movements of the femoral component were constrained to be planar: moving in the axial, coronal and sagittal planes around the z , y , x axes respectively (see Figure 3a, Figure 4a). These planar movements corresponded with the following femoral component movements: sagittal plane movement around the x axis for flexion and extension; coronal plane movement around the y axis for abduction and adduction; axial plane movement around the z axis for internal and external rotation.

Total ROM (in degrees) of rotation were recorded from maximum negative rotation and maximum positive rotation around each axis. Minimal and maximal points were determined when femoral neck component impingement (collision) with liner were detected in the CAD models. ROM was measured with the liner lip in two positions, with the elevated lip superior (with 15 degrees of posterior rotation) and inferior (Figure 2b).

Additionally, one mixed movement scenario was simulated where the femoral component was rotated in the axial plane (around the z axis) with the femoral component positioned in 90 degrees flexion (rotated anteriorly by 90 degrees around the x axis).

Results

In Table 1, hip flexion, extension and abduction was greater when the elevated lip liner was positioned in the inferior position compared to the superior position. Hip adduction, internal and external rotations were greater when the liner was positioned in the superior position. The results of the combined movements of rotation around the three axes with the stem held in 90 degrees of flexion considering the clinical relevance of this particular movement are presented in Table 2 and illustrated in Figure 4b.

This shows that an inferiorly placed lip will allow more than twice the amount of internal rotation in a flexed position when compared with the lip positioned postero- superiorly.

Table 1.

Femoral component direction	Angle difference in degrees (inferior lip liner compared to superior lip liner)
Flexion	17.2°
Extension	37°
Abduction	16.8°
Adduction	-17°
Internal rotation	-18.6°
External rotation	-18.2°

Table 2. ROM of femoral stem component for rotation in the coronal plane with the femoral component at 90° flexion

Liner Lip Position	Internal (superior) rotation in the coronal plane	External (inferior) rotation in the coronal plane
Superior	16.8°	143.6°
Inferior	35.2°	130.6°

Discussion

Dislocation continues to be a major complication after total hip arthroplasty [2]. The causes of dislocation can be generally ascribed to four factors: soft tissue tension; soft tissue function; component design; component position [25]. These can, in isolation or in combination, result in a dislocation.

Component design and component position are the fac-

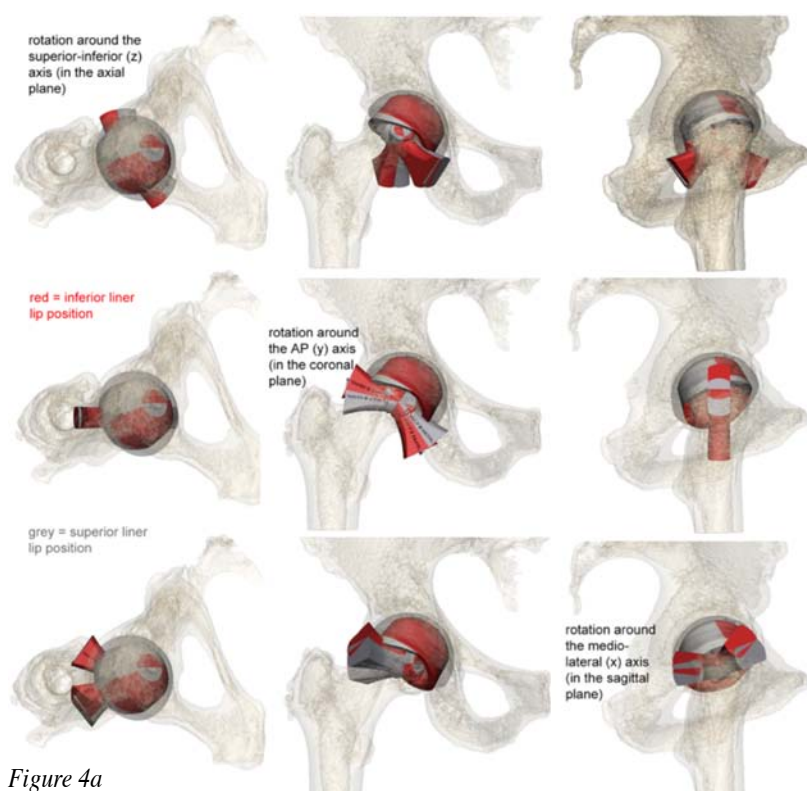


Figure 4a

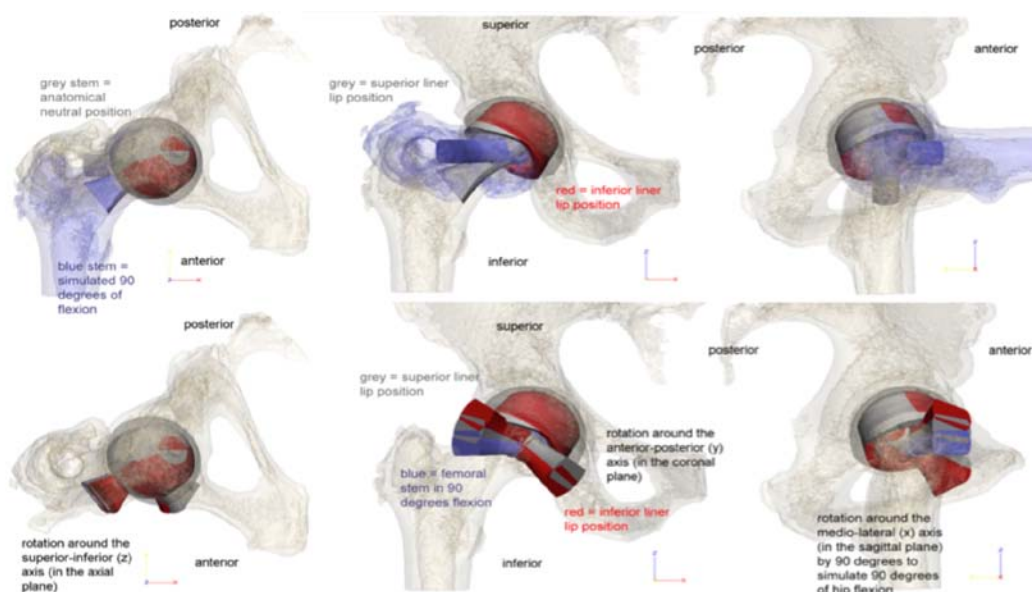


Figure 4b

Figure 4a) Assessment of 'primary arc' range with Lip in variable orientations. 4b) Images show (left to right) construct in axial, coronal and sagittal planes. Top images show the simulation of the femur and femoral stem component in 90 degrees of flexion. Bottom images show the combination movements in the three planes with the femoral stem starting in 90 degrees of flexion.

tors where mechanical impingement is thought to be the culprit and the earlier discussed concepts of primary arc and jump distance come into play [11,26]. Most dislocations are thought to occur secondary to mechanical impingement [25] and much literature discusses dislocation secondary to femoral-neck-on-liner impingement with im-

pingement damage shown on retrieval studies [14,27,28]. Elevated lip liners were first used by Charnley in the early 1970s to prevent posterior or hip dislocation and more recently have been shown to increase stability [10,9,26].

Our results show that an inferior placement of the elevated lip liner allows increased effective coronal (abduction) as well as sagittal plane range of motion for the femoral component (Figure 4a, Figure 4b, Table 2, Table 3).

Our study shows that an increase in range in flexion, extension and abduction with an inferiorly placed liner lip but a reduction in rotation and adduction. But is this likely to have a negative effect by increasing impingement? Reduction in ROM due to early impingement is undesirable, however, is the reduction in rotation and adduction of any clinical significance? To answer this question, we need to know what the physiological range of motion should be.

There are various studies [5-6] looking at native hip ranges which indicate that the reduction of range in rotation as a result of the extended

lip being inferiorly placed is not, for the vast majority of the population, an issue. This is because the overall arc of motion in rotation should be approximately 150 degrees [5]. The loss of motion of 18 degrees (from an inferior lip) will result in a residual arc of over 110 degrees, which is greater than the axial rotational arc in most studies [5-6].

Physiological hip rotational studies show limited data on normal hip rotation range of motion in adults. Kouyoumdjian et al. noted rotation in bilateral physiological hips to be symmetrical with predominance

for external rotation [29]. Cibulka et al found external rotation to be predominant in 52% of patients [30]. Widmer et al. defined the ideal total hip replacement range of motion was 60 degrees of external rotation and 40 degrees of internal rotation [31].

Whether this is enough for an impingement free ROM

Table 3. Ranges of motion reported in the literature

Movement	Flex	Ext	IR	ER	Abd	Add	Paper
Range	120°	30°	45°	45°	45°	35°	Turley et al [4]
	113°	28°	45°	45°	48°	31°	Boone et al [6]
	120°	9.5°	32°	33°	39°	30°	Roaas et al [7]
In 90° flex			38°	40°			Kouyoumdjian et al [5]

in-vivo is beyond the scope of the present study. This study does not include soft tissues in the model, which can potentially cause as well as prevent impingement by altering or limiting the ROM arc.

Of clinical relevance, an inferiorly placed elevated lip will increase jump distance postero-inferiorly. The relevance of this is in combined ROM, in particular flexion and internal rotation where the impingement is between the antero-superior acetabulum (or soft tissues) and anterior neck. This is a common direction of dislocation (as when sitting in a low chair or internally rotating whilst getting up from a seated position) and as such there may be some benefit in positioning of the lip in this location without the consequent loss of primary arc. For impingement on the inferiorly placed lip to occur, one would have to externally rotate > 140 degrees (Figure 4a), which is well outside the physiological ranges for function.

With paucity of data in the literature regarding lip liner position that may improve hip stability, biomechanically and with soft tissue effects aside, our study shows that an inferiorly placed lip liner will allow increased hip abduction compared to a traditionally superiorly / postero-superiorly placed lip liner. Whilst abduction is generally a safe position unless in extreme range (as in performing a split) and therefore not of concern in the vast majority of hip replacement patients the value of increasing inferior jump distance may be in mixed abduction and flexion activities (riding a horse or a jetski) as demonstrated above. Further,

range (allowance and restriction) and potential impingement [32].

The ROM results presented in the present study were mainly monoplanar, except the one combination movement tested of flexion with internal/external rotation. This simple model does not take into account complex movements of the hip joint that a patient may sometimes undertake in their daily living. However, accounting for the above, based on our results, an inferiorly placed lip is likely to be protective in particular mixed movement that are traditionally part of the 'hip precautions' i.e., avoidance of flexion/IR, and as such may have significant merit. Optimum implant position for that patient is still a prerequisite.

Conclusion

The findings of this study indicate that, provided optimum implant position for that patient, an inferiorly placed elevated lip liner, may provide additional stability with hip abduction and possibly in combined flexion/IR thus allowing patients a greater range of motion in those planes before dislocation can occur.

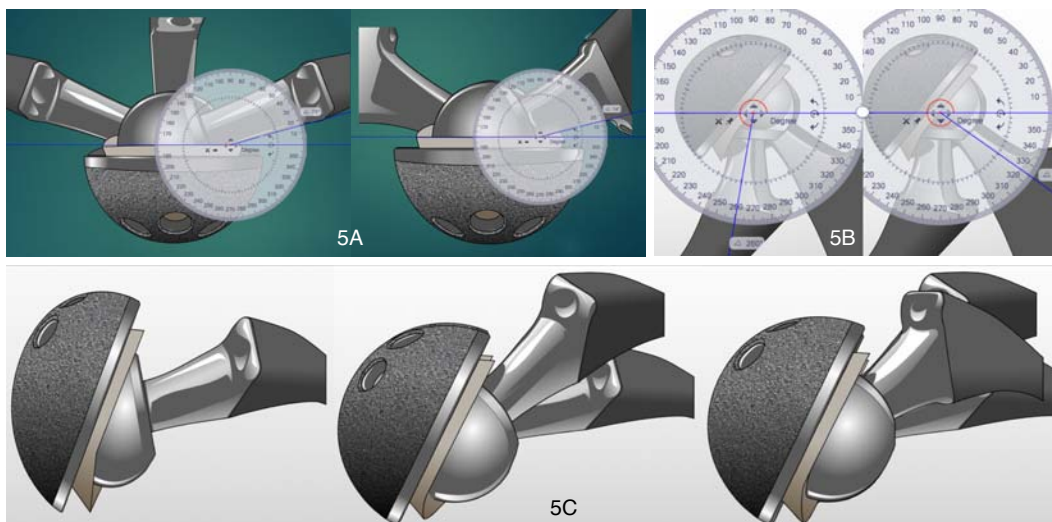


Figure 5a) Rotation and Abduction/ Adduction arc limited by implant design with no lip. b) Adduction range with inferior position of Lip liner c) 3D representation - Flexion, Flexion / Adduction, Flexion/ Adduction/IR

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SUBMISSION HISTORY

Submitted October 10, 2017
 Reviewed November 11, 2017
 Revised November 19, 2017
 Accepted December 14, 2017
 Published December 31, 2017

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AUTHOR DISCLOSURES

The authors declare there are no disclosures regarding the publication of this paper.

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Bio-Occlusive Gauze with Tegaderm: A Dressing for Surgical Wounds in Primary THA and TKA

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Abstract

Background: We introduce a simple, cost-effective bio-occlusive dressing to be used for primary total hip arthroplasty (THA) and primary total knee arthroplasty (TKA).

Methods: The gauze-Tegaderm™ (GT) dressing consists of a 5cm wide 8-layered gauze covered by 3 to 5 medium-sized Tegaderm transparent films. We prospectively evaluated 100 consecutive primary THA's and 107 consecutive primary TKA's utilizing this dressing with a minimum of one-year follow-up.

Results: In the primary THA group, there was one surgical site infection (SSI) requiring oral antibiotic treatment. There were no cases of periprosthetic joint infection (PJI). In the primary TKA group, there were two surgical site infections requiring oral antibiotic treatment and one case of chronic PJI requiring a two-stage exchange protocol.

Discussion: Our SSI and PJI rates are comparable to published rates in the literature. The GT dressing is a simple, inexpensive dressing that can compete against the many proprietary bio-occlusive dressings that are more expensive and are not readily available worldwide. Our favorable review has merited a large volume randomized controlled study comparing the GT dressing to another proprietary bio-occlusive dressing.

prevalence of degenerative joint disease. Currently, it is estimated that more than 2 million total hip arthroplasty (THA) and total knee arthroplasty (TKA) procedures are performed worldwide [1,2]. Although these total joint arthroplasty (TJA) procedures are very successful, periprosthetic joint infection (PJI) is a major complication that occurs at a steady rate worldwide. The combined PJI rate for primary THA and TKA procedures is estimated to be between 1-6% [3,4]. This is a major challenge to all healthcare institutions and personnel, as the cure requires an inordinate amount of time and consumes a significant portion of one's healthcare budget. As a result, in the last decade, PJI prevention has been emphasized by governmental and healthcare organizations. Methods to reduce PJI include preoperative optimization of the patient's health, pre-admission skin cleansing, and adherence to strict intra-operative measures to reduce joint implant microbial colonization. Additionally, post-operative wound care measures have been highlighted to reduce the rate of local surgical site infections (SSI) that can progress into a PJI. Consequently, the healthcare market has seen a proliferation of various wound dressings as a means to reduce SSI.

The aim of any post-operative wound dressing is to absorb wound blood and exudate while reducing local bacterial load to the surgical site. Furthermore, the dressing should

Background

As the world population continues to rise, so does the

Keywords: Postoperative, Dressing, Bio-Occlusive, THA, TKA, TJA, Gauze, Tegaderm, Primary, Arthroplasty, SSI, PJI
Level of Evidence: AAOS Therapeutic Level IV
Educational Value & Significance: JISRF Level A

keep the environment around the wound moist enough to prevent desiccation and accelerate natural wound healing [5]. Many companies have developed bactericidal/bacteriostatic dressing coverings to mitigate SSI. All advertised dressings report effective reduction of SSI to some degree, but the costs of such dressings are relatively expensive. With the costs of healthcare rising throughout the developed world, all healthcare personnel are cognizant of providing effective treatment at lower costs. This applies to all aspects of perioperative total joint arthroplasty (TJA) care, including perioperative dressings.

In this review, we introduce a simplified surgical dressing that we believe provides effective treatment of perioperative TJA wounds. The design consists of an 8-layered simple gauze dressing covered with an occlusive polyurethane film (Tegaderm™, 3M, St. Paul, MN). It is simple, readily available, and economical. The gauze dressing over the wound acts as a highly absorbent pad to absorb any excess exudate as well as keeping the immediate surroundings moist. The occlusive polyurethane film (Tegaderm), applied over the gauze, provides a waterproof seal to the wound. It still allows for the exchange of water vapor while inhibiting the entry of bacteria. This keeps the wound moist as well as free from any external contaminate [6]. It serves as a significantly cheaper alternative to its counterpart dressings currently available on the market. To date, to the best of our knowledge, no study has shown the effectiveness of this particular dressing combination in terms of prevention of SSI and PJI, nor the calculated reduction in the cost for the healthcare system. The objective of this study was to evaluate the effect of using this dressing combination on the occurrence of PJI and SSI. We compare our results to the reported rates in the literature. In addition, we assess the financial impact of utilizing this simple perioperative dressing. We hypothesize that the Gauze-Tegaderm dressing combination will be as effective as other “modern” dressings discussed in the literature while providing a significant cost savings.

Methods

Between January 2015 and December 2016, 796 TJA procedures were performed at our single TJA quaternary referral institution by the senior author (ejm). The TJA procedures included total shoulder arthroplasty (TSA), total hip arthroplasty (THA), and total knee arthroplasty (TKA). During this time period there were 395 revision TJA procedures, 115 resection TJA procedures, 52 reimplant TJA procedures, and 234 primary TJA procedures. We selected our primary THA and primary TKA procedures as the basis for this study. Beginning January 2015, we started the pro-

spective study in which we covered all consecutive primary THA and TKA procedures with a gauze-tegaderm dressing combination. We selected a minimum follow-up period of one year for this report.

The constituents of the gauze-Tegaderm (GT) surgical dressing are sterile 4x4 inch gauze dressing pads (Medline, Mundelein, IL) and 4x4.75 inch Tegaderm™ Film covers. The technique of assembling and applying the GT dressing was the same for THA and TKA procedures; this technique remained constant over the entirety of the study period. The dressing assembly required unfolding 4 sterile gauze dressings and laying them on top of one another. Next, the 4 layers were folded in half to a width of 2 inches (5.08cm). The now 8-layered gauze was applied over the surgical site and any excess at the ends was cut off. The gauze was then covered with the Tegaderm films. The films were overlapped approximately 1cm to provide an impervious seal of the surgical incision. They were applied in a fashion to have at least 2cm of skin contact circumferentially around the gauze dressing. For THA procedures, the GT dressing was applied at the termination of the surgical procedure with the patient in the lateral decubitus position. Prior to the application of the dressing, the skin was cleaned with sterile saline solution via a laparotomy sponge (Medline, Mundelein, IL) and completely dried with a dry laparotomy sponge. The Tegaderm was applied over the gauze and gently pushed onto the skin. We were strict not to stretch the Tegaderm during application in the interest of preventing skin blistering. For TKA procedures, the GT dressing was applied at the termination of the surgical procedure with the knee flexed at 90°. The skin was cleaned and dried in a similar fashion to the THA application. Again, the Tegaderm was gently pushed digitally onto the skin avoiding any stretching of the cover. For all primary TKA procedures we used a joint drain that was exited over the lateral mid-thigh. The drain was secured with a smaller 4x3cm GT dressing. The GT dressing applications are illustrated in Figures 1a-1c.

Dressing changes were performed on the surgical floor when blood or serous fluid extended to the edge of the gauze. If the surgical dressing required a change, a similar dressing was reapplied after cleaning the surgical site with alcohol pads and/or sterile dry gauze. If the surgical dressing remained dry and intact, the patient was discharged with instructions to remove the dressing on post-operative day 7 or 8. Patients were allowed to shower with the waterproof GT dressing. Similarly, if the dressing was changed, the patient was discharged with the last GT dressing and instructed to remove the dressing on post-operative day 7 or 8.

All THA procedures were performed using a less invasive posterolateral incision [7]. The patient was positioned and secured in the lateral decubitus position utilizing the Hip



Figure 1(a-c): Photographs demonstrating application of Gauze-Tegaderm (GT) dressing in Primary TKA cases.

Grip System (SunMedica, Redding, USA). The entire limb, hip, and pelvis were first cleansed and wiped with 70% isopropyl alcohol wipes (McKesson, Santa Fe Springs, USA) and allowed to dry. The entire limb, hip, and pelvis were treated with DuraPrep™ (3M, St. Paul, USA) and draped sterilely with disposable paper drapes. Exposed skin surfaces were covered with an Ioban™ dressing cover (3M, St. Paul, USA) that was removed at the termination of skin closure. A first generation cephalosporin (Ancef, Baxter International, Deerfield, USA) was administered intravenously 30 minutes prior to incision and continued for 24 hours. If a patient stated an allergy to penicillin, a test dose of Ancef was administered and, if after 15 minutes there was no observable reaction, IV Ancef was continued. If the patient had a known or documented allergy to Ancef, IV 1 gram Vancomycin was administered prior to incision and was continued for 24 hours. Throughout the procedure, the tissues were injected with a periarticular joint cocktail for pain management. The pain block cocktail is listed in Table 1. The tissues were strategically injected with a multi-stab technique with a 23 gauge needle [8].

The hip incision was made long enough to allow for comfortable access and exposure to the hip. A cementless acetabular cup was used in all cases. A titanium, porous plasma spray hemisphere cup was inserted (Magnum or Ranawat Burstein, Biomet, Warsaw, USA) with a press-fit technique of a 1mm underream. Just prior to implant insertion, the acetabular bone was hand lavaged with 100 to 150cc of sterile saline solution containing 1 gram of Bacitracin (APP Pharmaceuticals, Schaumburg, USA) mixed in one liter of sterile saline solution. For the femoral stem, a cementless stem was used in all cases (TaperLoc, Biomet, Warsaw, USA). This was a titanium alloy, proximal, porous plasma spray ta-

Figure 1a. 64-year-old male on post-operative day one. The GT dressing covers the knee incision and drain site. Notice the blood stain on the inferior part of the gauze (highlighted in black marker). The transparent Tegaderm allows visualization of the gauze dressing underneath. The dressing is changed when the underlying gauze becomes stained from edge to edge with fluid and/or blood.

Figure 1b. 70-year-old female on post-operative day two. The GT dressing on the drain site has been removed. The GT dressing completely allows knee flexion to 90 degrees without irritating the skin. This patient went home with this dressing, which was removed by the patient on post-operative day seven.

Figure 1c. 68-year-old male with staged primary TKAs one week apart. The GT dressing was applied on the initial TKA (left), seen on post-operative day 8. For demonstration, we applied the bio-occlusive Aquacel dressing on the contralateral knee, seen on post-operative day two. Note how the Aquacel dressing pulls upon the lateral skin. This type of pulling force can cause skin blisters with repetitive knee range.

pered stem. The femoral canal was prepared by serial broach technique utilizing a 0.75mm undersized press-fit at stem insertion. Prior to stem implant insertion, the femoral canal was lavaged with 100 to 150cc of sterile saline solution containing Bacitracin. The acetabular and femoral stem implants were inserted using a “no touch” technique as much as possible. Prior to closure the entire wound was hand la-

Table 1. Periarticular Pain Block Cocktail (Primary TKA & THA)

20cc Bupivacaine Liposome (Exparel®)
+
1cc Methylprednisolone Acetate
+
2cc Ketorolac Tromethamine
+
25cc Bupivacaine HCl with Epinephrine (5mg/mL)
Total Volume = 48cc
Not Diluted with Sterile Saline

vaged using a 25cc Asepto syringe (McKesson, San Francisco, CA) with 200 to 250cc of sterile saline solution containing Bacitracin. The top surgical gloves were changed at the beginning of closure (double glove technique was employed for all surgical personnel). A multilayered closure was performed using all absorbable sutures. Number One Vicryl and 2-0 Vicryl (Ethicon, Somerville, NJ) sutures without antibiotic coating were used for all layers. The skin was closed with a subcuticular technique using 3-0 Monocryl (Ethicon, Somerville, USA). The skin was reinforced with ½ inch steristrips (3M, St. Paul, USA) cut to a width of 2.5cm so that they would be covered by the GT dressing. The steristrips were applied with a thin application of Benzoin (3M, St. Paul, USA) applied only to a width of 2.5 cm of the skin.

All TKA procedures were performed using a less invasive paramedial incision with a medial parapatellar arthrotomy [9]. The knee and limb were secured utilizing the Knee Grip System (SunMedica, Redding, USA). The entire limb was initially cleansed with alcohol wipes and allowed to dry. A pneumatic tourniquet was applied into the most proximal thigh. The tourniquet pressure was 275mm/Hg in all cases. The tourniquet was inflated prior to skin incision and deflated after cementing of the implants. The entire limb was treated with Duraprep and draped sterilely with disposable paper drapes. Exposed skin surfaces were covered with an ioban dressing cover. The ioban was removed at the termination of skin closure. Intravenous antibiotics were administered using the same protocol as the THA procedures. Additionally, the same periarticular pain block cocktail was injected into the knee tissues. For all TKA procedures, an adductor block using 20cc of 0.5% Ropivacaine was administered prior to the surgical procedure.

The knee incision was made long enough to allow for comfortable access and exposure to the knee. The Vanguard Total Knee System™ (Biomet, Warsaw, USA) was used in all cases. An anterior stabilized Vitamin E reinforced polyethylene bearing was used in all cases except when a constrained knee system was required for severe deformities. All patellae were resurfaced with a polyethylene 3-peg dome. All implants were cemented with Palacos Cement (Biomet, Warsaw, USA) without antibiotics added to the PMMA powder. Prior to cementing of the implants, all bony surfaces of the knee were pulse mechanical lavaged with sterile saline solution containing Bacitracin. Top gloves were changed for insertion of implants and also changed at the time of closure of the knee. Just prior to closure, the knee was lavaged with 1 liter pulsed mechanical lavage using sterile saline solution containing Bacitracin. All layers of the knee incision were closed at 90° of flexion, including the subcuticular layer. A 10 French Blake wicking silicone drain (Ethicon, Somerville, USA) was placed into the lateral

gutter of the knee and brought out of the skin at the antero-lateral mid-thigh. The drain was removed on the first post-operative day. A multilayer closure was performed using all absorbable sutures without antibiotic coating. The arthrotomy was closed with number 1 and 2-0 Vicryl sutures. The subcutaneous layers were closed with 2-0 and 3-0 Vicryl sutures and the subcuticular layer was closed with a subcuticular technique using 3-0 Monocryl sutures. The skin was reinforced with 1/2" steristrips cut to a width of 2.5cm and applied with a thin coat of Benzoin. The skin was cleaned and dried prior to application of the steristrips, after which the GT dressing was applied.

All THA and TKA procedures were performed with body exhaust suits (Flyte, Stryker, Kalamazoo, USA) in non-laminar flow dedicated total joint rooms. Anesthesia consisted of a general anesthetic combined with a spinal anesthetic. Intrathecal morphine sulfate was not used in any cases. Patients were started in physical therapy within 6 hours of the procedure with standing and walking. For thromboembolic prophylaxis, a graduated risk assessment protocol was utilized by the medical team. The default, low risk, patients were treated with mechanical foot pumps and enteric coated aspirin (325mg) daily. Higher risk patients were treated with other antiplatelet inhibitors or oral warfarin with a target INR of 2.8 to 3.0. On rare occasion, the very high-risk patients were treated with a pre-operative removable inferior vena cava filter, which was removed 3-4 months after the joint replacement procedure.

Preoperatively, all patients were scored for periprosthetic joint infection risk using the Musculoskeletal Infection Society (MSIS) risk scoring system, calculating both a systemic host grade (A, B, or C) and a local extremity grade (1, 2, or 3) [10,11]. All patients were followed routinely at 6 weeks, 12 weeks, and yearly thereafter. Additional treatment was provided as needed. All complications or additional surgeries were documented. All clinical follow-up was with the operating surgeon. TKA procedures were evaluated with radiographs, Knee Society Scoring and Oxford Scoring at regularly defined intervals. THA procedures were evaluated with radiographs, Hip Society Scoring, and Oxford scoring at regularly defined intervals. When there was any suspicion of a PJI, the patient was assessed with serum blood testing. This included Complete Blood Count (CBC), quantitative c-reactive protein levels, and an erythrocyte sedimentation rate (ESR). When indicated, all joint aspirations were performed by the operating surgeon. All cultures were sent for a 14-day bacterial growth protocol. Fungal and mycobacterial plates were reviewed for a 6-week duration. A PJI was defined using the major and minor criteria as set forth by the International Consensus on Periprosthetic Joint Infection [12].

Results

In this study there were 100 primary THA procedures in 91 patients and 107 primary TKA procedures in 100 patients. For the THA group, there were 48 females and 52 males. The average age was 72 (range 51-98). Average body mass index (BMI) was 27 (range 14-46). The main diagnosis for needing the THA procedure was primary osteoarthritis in 48 patients, developmental dysplasia (DDH) in 32 patients, acute femoral neck fracture with joint arthritis in 9 patients, rheumatoid arthritis in 5 patients, avascular necrosis in 3 patients, and acetabular fracture in 3 patients. The MSIS scores for the study group consisted of 51 A Hosts, 42 B Hosts, and 7 C hosts. Ninety-one patients had a Type 1 limb score (local extremity score), while 9 patients had a Type 2 limb score. Operative blood loss was measured and averaged 255cc (range 50-500). Four patients required a post-operative blood transfusion. The average incision length was 11.8 cm (range 9 to 15). The average number of Tegaderm films used was 3.4 (range 3-5). The GT dressing was changed 44% (N=44) of the time prior to discharge. Table 2 displays the calculated total costs of the THA dressing application and compares this to an estimated cost of a silver-impregnated occlusive wound dressing (10-inch Aquacel™, ConvaTec, Deeside, UK) that is available at our institution. At latest follow-up, an average of 18.1 months (range 12.9 to 24), there were no cases of PJI. No patients required additional surgery for an SSI or wound drainage. Two patients were prescribed oral antibiotics at their 6-week post-op evaluation for redness surrounding a localized suture reaction (i.e., “split sutures”). There were 3 reoperations performed. One patient dislocated at 3 weeks post-operatively, requiring an open reduction and revision of the acetabular cup. One patient underwent a removal of heterotopic bone at 10 months for symptomatic pain with hip flexion limited to 80°. One patient required revision at one week due to peri-prosthetic fracture of the femur. Other compli-

cations were encountered that did not necessitate reoperation. One patient suffered from bilateral DVT at 12 weeks post-operatively. Another patient had a partial femoral nerve palsy with post-operative quadriceps power as 3/5. This fully recovered. Lastly, one patient had a non-displaced greater trochanteric fracture intra-operatively that did not require any further intervention.

For the TKA group, there were 66 females and 41 males. The average age was 71 years (range 33 to 89). Average body mass index (BMI) was 26 (range 16-47). The main diagnosis for needing the TKA procedure was osteoarthritis in 90 patients, rheumatoid arthritis in 12 patients, and post-traumatic in 5 patients. For MSIS scoring, there were 54 A Hosts, 48 B Hosts, and 5 C Hosts. Eighty-seven patients had a Type 1 limb score (local extremity score), while 20 patients had a Type 2 limb score. The average measured intraoperative blood loss was 95cc (range 35-400). Only 1 patient required 1 unit of fresh frozen plasma preoperatively for known coagulopathy and cirrhosis. The average incision length was 12.4 cm (range 10-16). The average number of Tegaderm films used was 5.3 (range 5-7). The GT dressing was changed 45% (N=48) of the time prior to discharge. Table 2 displays the calculated total costs of the TKA dressing application and compares this to an estimated cost of the comparable Aquacel dressing. At latest follow-up, an average of 17.2 months (range 12.1 to 24), there was 1 case of PJI. This patient was successfully treated with a 2-stage revision arthroplasty. No other patients required additional surgery for SSI or wound drainage. Two patients were prescribed oral antibiotics at their 6-week postoperative evaluation for redness surrounding a localized suture reaction (i.e., split sutures). One patient also suffered from a loose tibial component 8 months postoperatively, requiring revision arthroplasty. Among complications not requiring reoperation, 4 patients developed joint arthrofibrosis requiring subsequent manipulation of the replaced knee joint, 1 patient suffered from a foot drop and fully recovered at 4 months, 1 patient had a DVT at 8 weeks, and 1 patient suffered from a superficial wound dehiscence requiring a wound vac. This was a patient with rheumatoid arthritis who went onto complete healing.

Table 2. Calculated Costs of GT Dressing Supplies with Comparison to Estimated Aquacel Costs

	Total # Dressing Applications Hip	Calculated Costs* – Hip (USD)	Total # Dressing Applications Knee	Calculated Costs* – Knee (USD)
GT Dressing	144	\$432.00	155	\$465.00
Estimated Comparable Aquacel Dressing	144	\$5,332.32	155	\$5,739.65

*At our institution the acquisition cost is \$0.08 (USD) for one 4"x4" gauze sponge pack (10 sponges) and \$0.59 (USD) for one Tegaderm film cover. A comparable Aquacel 3.5"x10" dressing cover costs \$37.03 (USD).

Discussion

Reduction of perioperative infection after total joint arthroplasty (TJA) is of paramount importance as infection is one of the most potentially disastrous complications that can occur. Superficial surgical site infection (SSI) can progress and result in deep peri-prosthetic joint infection (PJI). A PJI has enormous

consequences, not only to the patient, but also to the health-care community at large. Typically, a PJI requires reoperation to clear the infection and, if the acute PJI is not resolved, the implants require removal in either a single-stage or two-stage protocol. The costs of treating a chronic PJI could well pay for a further 10-30 primary TJA procedures.

Primary TJA wounds are classified as “clean,” acute wounds with only moderate exudation [13]. The wound exudate is rich in IL-1, PDGF, EGF, and TGF-beta, all of which modulate connective tissue formation and epidermal migration [14]. Winter’s research has demonstrated that a moist microenvironment enhances the wound healing process [15]. However, in some instances, some wounds can be highly exudative with persistent leakage. Ironically, this excess fluid could act as the breeding ground for microorganisms and cause infection. Thus, the ideal wound dressing should be able to absorb any excess exudate, but provide a moist microenvironment for optimal wound repair [16].

A unique challenge for the THA/TKA wound dressing is its direct application over a moving joint. The dressing must allow for functional range of motion, often over fragile elderly skin, without causing significant skin friction, shearing, and/or blistering. In addition, primary TJA is often associated with postoperative soft tissue edema, whereby there can be a substantial increase in skin circumference. Thus, a dressing must accommodate daily fluctuating skin circumference changes without causing significant skin friction and/or shearing. Any dressing that increases skin shear forces, increases the risk for blister formation. Blistering leads to breaks in the skin protective barrier and increases the risk of SSI [6]. Therefore, an ideal dressing should be flexible with range of motion and must accommodate cyclic fluctuations in periarticular joint circumference. Lastly, Odland’s research demonstrated that blisters heal faster if left unbroken [17]. Hence, a dressing with mechanical properties that limit blister formation and rupture would be ideal.

Cost conscious comprehensive medical care has become the normative process, competing against advancing medical technology and parabolic escalations in healthcare costs [18]. All aspects of orthopaedic surgical care are now carefully scrutinized with the advent of comprehensive medical informatics. Informatics programs allow comparisons of treatments between surgeons, OR teams, hospitals, and healthcare systems; providing effective safe treatment at reduced costs is the goal. The treating surgeon, going forward, will have to adapt to these changes and must take a leadership role in determining strategic changes in healthcare delivery that considers cost and benefit to both the individual patient and healthcare society in general.

Putting all criteria together, the characteristics of an ideal wound dressing for primary THA/TKA should include: 1)

protection against bacterial delivery at the surgical site, 2) maintaining an ideal microenvironment for wound healing while wicking excess exudate from the incision site, 3) visually transparent to determine the need for dressing change, 4) ability to adhere to the skin of a moving joint without causing significant skin blistering, and 5) inexpensive and readily available supplies for worldwide use.

At our center we selected the GT dressing as a means to address head-on the competitive field of occlusive postoperative dressings. Our basis for selecting this dressing specifically was multiple. First, Tegaderm is “easy” on the skin. It is thin and mechanically flexible, which is advantageous for application over a moving joint. Our previous experience using Tegaderm over ruptured skin blisters and skin tears showed that it caused minimal marginal dermatitis and blistering. Secondly, the GT dressing construct is a vapor-permeable occlusive film. An important characteristic of Tegaderm is its pore size; the pores are large enough to allow for the exchange of water vapor, but small enough to prevent bacteria from entering into the wound site. The GT dressing keeps the local wound environment moist, preventing excessive drying. Thirdly, the gauze dressing is a highly absorbent material that works on the mechanism of capillary action of its fine threads, effectively wicking fluid from the surgical wound. Furthermore, the white gauze beneath a transparent Tegaderm film allows for the treating physician to easily identify the color and volume of discharge from the wound below. This ease of identification also reduces unnecessary dressing changes. Frequent dressing changes cause episodic cooling of the wound, resulting in a longer time for resuming cellular mitotic activity and, in turn, wound healing [19]. Additionally, each dressing change poses a potential risk of exposing the wound to external nosocomial pathogens. Fourth, the GT dressing provides an essentially waterproof seal. This allows the patient to take a shower the next day postoperatively, if needed. With the skin cleaned and dried in the operating room, we have found that the Tegaderm can stay secure for an extended period of time. We have had patients with an intact GT dressing on the hip and knee for up to 14 days. Fifth, the GT dressing creates a hypoxic environment which has been shown to accelerate angiogenesis [15]. Both moisture and hypoxia are beneficial for wound healing. Lastly, the GT dressing is inexpensive and its supplies are readily available worldwide. At our institution, the cost of a typical GT dressing consisting of 4x4 gauze sponges and 5 medium-sized Tegaderm films is \$3.00 USD. A comparable length Aquacel dressing at our institution costs \$37.03 USD.

This review reports a favorable outcome of the majority of primary THA and TKA performed within this study group. We attribute our low overall infection rate to a disci-

plined comprehensive TJA protocol focusing on minimizing SSI and PJI. Our selection of the GT dressing for postoperative application did not appear to adversely affect our rates of SSI and PJI when compared to other published series [20]. Our low PJI rate is encouraging in light of our series having 49% B and C grade systemic hosts. The weaknesses of this study are several. First, this was not a randomized trial. Secondly, the total number of subjects studied was relatively small. Per design, we chose first to study the GT dressing construct to see if it was an acceptable dressing for continued use as a perioperative joint dressing for primary THA and TKA. After review of our results, we feel comfortable in stating that the GT dressing meets our criteria as a cost-effective dressing. Going forward, a more rigorous study is needed. At present, we have received IRB approval for a prospective randomized control trial comparing the GT dressing to a proprietary bio-occlusive dressing in primary THA and TKA. The enrollment will exceed 650 primary TJA procedures with a minimum follow-up of 1 year. This RCT will help determine via a rigorous comparison, whether the GT dressing will be equally effective in maintaining a low SSI and PJI rate in primary THA and TKA.

In summary, we introduce the concept of the gauze-Tegaderm dressing for use in postoperative primary THA and TKA wounds. This dressing construct meets a majority of criteria to promote wound healing and protect against SSI. The GT dressing has many salutary attributes and our study results show a low rate of SSI and PJI. The GT dressing, thus far, seems to be a reasonable cost-effective dressing that can be utilized worldwide. Our favorable early findings in this review merit a more rigorous investigation of this dressing. An upcoming large volume RCT will delineate the effectiveness of the GT dressing in minimizing postoperative SSI in TJA.

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SUBMISSION HISTORY

Submitted December 10, 2017
Reviewed December 15, 2017
Revised December 20, 2017
Accepted December 21, 2017
Published December 31, 2017

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AUTHOR DISCLOSURES

The authors declare there are no disclosures regarding the publication of this paper.

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Periprosthetic Distal Femur Fractures: Review of Current Treatment Options

Head J¹

Abstract

The geriatric population in general and specifically recipients of total knee arthroplasty (TKA) have increasing functional demands along with an increasing life expectancy. Certain intraoperative aspects of the index procedure, revision TKA, or the patient's physiology (i.e.- osteoporosis, rheumatoid arthritis, neurologic disease) predispose the patient to post-operative periprosthetic distal femur fractures (PDFF). This review describes the epidemiology, classification, examination, and treatment options of PDFF. Osteoporosis and intraoperative anterior femoral cortex notching are primary patient and surgeon specific factors, respectively. The two most commonly used classification systems were described by Rorabeck and Kim and should be used to guide the surgeon's choice of treatment. The non-operative treatment of PDFF is rare, requires close radiographic follow up, and delayed union is common. Open reduction with internal fixation (ORIF) is best accomplished with minimally invasive techniques and distal locking screws. Retrograde, intra-medullary nail fixation is technically difficult, but provides earlier weight bearing and comparable time to union as ORIF. Revision TKA is indicated in patients with adequate bone stock, a simple fracture pattern without ligamentous instability, and a loose or malaligned femoral component. Allograft-prosthetic composite (APC) or distal femoral replacement (DFR) is indicated for patients presenting with a PDFF about poor or deficient bone stock. Patients with PDFF present a challenge to the arthroplasty surgeon in regards to choice of treatment and increased morbidity and mortality post-operatively. Close follow up is required and fracture union is often delayed.

Background

Total knee arthroplasty (TKA) is one of the most commonly performed, elective orthopedic procedure in the United States; with an estimated 4.7 million living recipients in the United States [1]. As patients' average life expectancy and functional demands increase, the number of patients who undergo TKA will increase and, hence the incidence of serious post-operative complications, including periprosthetic distal femur fractures (PDFF), will likely increase proportionately.

Periprosthetic fractures about a total knee, occurring intraoperatively or postoperatively, present a challenge to the surgeon. Multiple host factors including osteoporosis and other comorbidities (ie. poor bone stock, quality of previous implant fixation) affect treatment options [2,3]. Additionally, the fracture pattern may disrupt ligamentous attachments of the distal femur, causing instability of the knee and require the use of a constrained prosthesis [4]. Multiple options exist for treatment of PDFF and the general orthopedic surgeon should be well versed in the optimal fixation paradigm for a particular fracture pattern. The purpose of this review is to define the epidemiology, pathogenesis, and classification of PDFF, review the literature regarding fixation strategies, and suggest a treatment algorithm to aid in surgical planning.

Keywords: total knee, complication, periprosthetic fracture, revision total knee, osteoporosis, femoral notching

Level of Evidence: AAOS Therapeutic Level III

Educational Value & Significance: JISRF Level B

Epidemiology

Among distal femur periprosthetic fractures, the supracondylar region is most commonly affected and has been reported to occur in 0.3% to 2.5% after primary TKA and 1.6% to 38% after revision TKA [3,5,6,7,8,9]. However, these data likely underestimate the true incidence as many fractures go unnoticed or are treated non-operatively and subsequently not reported. Numerous host factors predispose patients to PDFF; chief among them is osteoporosis. An estimated 9 million osteoporotic fragility fractures occurred in the year 2000 and this specific comorbidity is directly associated with an increased incidence of PDFF [10,11]. Meek, et al reported on the Scottish Registry of 4,451 primary total knees and 3222 revision total knees and identified female sex, age greater than 70, and revision surgery as risk factors for subsequent PDFF [12]. Additionally, rheumatoid arthritis, prolonged steroid therapy, and neurological diseases significantly increase the risk of PDFF [7,13,14,15].

Technical aspects of the index procedure may predispose a patient to subsequent PDFF. Shawen, et al., using 13 matched pairs of cadaver femora, demonstrated that a 3mm anterior cortical defect (ie- “notching”) significantly decreased torsional load to failure and further demonstrated that fracture risk is increased in osteoporotic, notched femora [11]. In another cadaveric biomechanical study, Lesh et al. showed that full-thickness notching of the anterior cortex significantly lessened the load to failure by decreasing the bending strength by 18% and torsional strength by about 40% [16]. Interestingly, clinical outcomes that validate these theoretical laboratory findings are lacking and several series have not correlated anterior femoral notching to an increased incidence of subsequent PDFF [17,18]. In a finite element analysis, Conlisk, et al. demonstrated that a well-placed distal femoral implant significantly increased the stresses about the anterior cortex and stresses and strains were dramatically increased in models of osteoporotic bone and when the knee was under increased flexion angles [19]. Considering that approximately 26% of the United States population over the age of 70 years has a total knee replacement and the concomitant health burden of osteoporosis in this population, it is not surprising that female sex and age over 70 represent significant risk factors to PDFF [10,12].

Classification

Although many classifications of supracondylar femur fractures have been developed, Lewis and Rorabeck pro-

posed their now widely used system based on the original Neer classification. Their classification considers fracture displacement and the stability of the prosthesis in order to guide management and is summarized in table 1 [8]. Type 1 fractures are non displaced fractures about a stable prosthesis, type 2 fractures are displaced greater than 5mm or 5 degrees, but the prosthesis remains stable, type 3 includes displaced and non-displaced fractures about a loose or failing prosthesis secondary to instability or advanced polyethylene wear.

Type	Fracture Description	Component Description
1	Nondisplaced	Femoral component intact
2	Displaced >5mm or 5°	Femoral component intact
3	Nondisplaced or Displaced	Femoral component loose or failing

Table 1. PDFF classification proposed by Lewis and Rorabeck. The fracture is described as nondisplaced if less than 5mm translation or 5o angulation. Femoral component stability is based on radiographic evidence of osteolysis, indicating a loose or failing prosthesis.

An alternative classification proposed by Kim, et al (table 2) considers the bone quality, ability to reduce the fracture, and the position and quality of fixation of the femoral prosthesis, thereby guiding management [20]. Type 1 fractures occur in a stable, well-aligned prosthesis; type 1A are non-displaced or reducible fractures treated by closed means while type 1B are irreducible and require open reduction and internal fixation. Type 2 fractures are reducible with good bone stock but a loose or maligned component, which requires revision arthroplasty with a long stemmed component. Type 3 fractures are severely comminuted with poor distal bone stock with a loose and maligned component and necessitate the use of a distal femoral replacement.

Type	Fracture Description	Bone Quality	Component Description
1A	Nondisplaced or easily reducible	Good bone stock	Stable femoral component
1B	Require open reduction	Good bone stock	Stable femoral component
2	Nondisplaced or easily reducible	Good bone stock	Unstable femoral component
3	Severe comminution	Poor bone stock	Unstable femoral component

Table 2. PDFF classification by Kim, et al. This system utilizes the patient's bone stock, ease of fracture reduction, and component stability in order to guide treatment.

Examinations

Initial workup of PDFF includes standard anteroposterior and lateral knee radiographs that include views of the entire length of the femur. Scrutiny of the implants for any signs of loosening or migration is essential and includes identification of any radiolucencies at the bone/cement/implant interfaces and comparison to any available previous radiographs. If signs of loosening and osteolysis are noted, then a thorough infectious workup to include: serological markers (ESR and CRP) and preoperative joint aspiration with synovial white cell count (WCC), polymorphonuclear (PMN) cell proportion and microbiological analysis. In a recent prospective study, the Alpha-defensin immunoassay test was found to have a sensitivity of 97% and specificity of 97% for diagnosing periprosthetic joint infection and is now recommended to be included in the workup [21]. Antecedent knee or thigh pain may indicate pre-existing component loosening and should be included in the history. Further studies include CT to characterize the fracture pattern, evaluate bone stock, and evaluate the implant's relationship to the fracture.

Treatment

Non-operative treatment

Rarely, non-operative treatment can be considered for stable fractures with minimal displacement, good host bone stock, and a well-fixed and well-aligned component, i.e. Type 1 fractures [20,22]. These fractures comprise the minority of presentations, as the deforming forces about the knee cause angular deformity and displacement; with the typical pattern of the distal fragment aligned in varus, adduction, and internal rotation [3].

Stable fractures of the distal femur with acceptable alignment can be managed with cast or brace immobilization and protected weight bearing, followed by range of motion exercises [23]. Close radiographic observation is required and surgical intervention may be necessary if subsequent displacement is observed. The surgeon must be prepared for prolonged healing, with some fractures taking up to 4 months to demonstrate stable union [6]. In a comparison study of 61 PDFF in 58 patients with mean follow up of 3.7 years, Culp et al treated 31 fractures in 30 patients with operative treatment and 30 fractures in 28 patients conservatively with casting or traction. The group treated conservatively had a higher malunion and non-union rate (46%) than the group treated surgically (13%). Ambulatory status was negatively affected following conservative treatment, with 50% of patients seeing a change.

The surgical fixation group saw 13% of patients' ambulation affected following treatment [7].

Operative treatment

When indicated, surgical planning is guided by implant stability, fracture pattern, presence of infection, and periprosthetic bone stock. The goal of stable fixation is to restore limb length, maintain anatomic alignment, ensure proper axial rotation, and allow for early mobilization. Patient optimization is paramount in order to minimize morbidity and mortality. In cases with a stable femoral prosthesis without evidence of infection, ORIF or treatment with an intramedullary implant is indicated. If implant instability, septic joint, or osteomyelitis is suspected, then revision arthroplasty is the treatment of choice.



Figure 1. Radiographs showing successful distal locking plate ORIF treatment of a supracondylar periprosthetic femur fracture above a stable total knee arthroplasty (Lewis and Rorabeck 2, Kim 1B). A, Injury AP view. B, Injury lateral view. C,D, AP and lateral views at 12-month follow-up show a healed fracture with acceptable alignment. (From Ricci, et al, *J Orthop Trauma*. 2006;20:190–196).

Open Reduction Internal Fixation

Of the two options available to the surgeon, locking plates have seen reproducible results with good or excellent outcomes compared to conventional plate technology. Recently, locking plates have completely replaced angled blade plates (ABP) and dynamic condylar screws (DCS). This is due to the former having better outcomes in osteoporotic bone with comminution, limiting soft tissue com-

promise with minimally invasive instrumentation, and available polyaxial screw options that specific fragment fixation [24,25,26,27,28]. Figure 1 shows a PDFF amenable to repair with ORIF [27].

In a cohort study, Hassan et al demonstrated a satisfactory union in 96% of patient treated with locking plates. The authors cautioned against allowing full weight bearing until 3 months post-op and noted that delayed union up to 6 months may be observed [29]. In a case control study of 12 patients, Norrish et al demonstrated union in 11 of 12 PDFF treated with the LISS (Less Invasive Stabilization System, Synthes USA, West Chester, PA) implant. Mean time to union was 3.7 months [30]. Streusel et al compared PDFF fixation with distal femoral locking plates in fractures proximal to the femoral component in 28 patients and in 33 patients where the fracture propagated distal to the well-fixed component. No difference was observed in malunion, nonunion, delayed healing, hardware failure, or infection; thus demonstrating the utility of locking screws in extreme distal PDFF [31]. Importantly, the use of minimally invasive techniques have demonstrated higher union rates, earlier return to pre-injury functional status, and fewer soft-tissue complications [26,32,33].

Intramedullary (IM) Nail Fixation

Load-sharing IM nails are an attractive fixation option for PDFF. These rigid, load sharing devices offer stable fracture fixation with preserved soft tissue envelope with quicker return to weight-bearing and fewer union complications than ORIF [34,35,36]. Important to the pre-operative plan is using a compatible IM nail in regards to the intercondylar distance and anterior to posterior position of the femoral component notch. Thompson et al produced a convenient reference table for popular TKA designs with nail compatibility [37]. Often, the notch forces the starting point of a retrograde nail posterior to Blumensaat's line and inherently predisposes to recurvatum deformity and malalignment [38]. A representation of this treatment option and the characteristic post-operative deformity is shown in figure 2.

There is a paucity in the literature comparing cohorts treated with laterally-based locking plates to IM nail fixation. In a study of 91 patients, 29 were treated with an IM rod while 66 received periarticular locking plates. A trend toward nonunion was observed in the locked plating group, 19 vs 9% in the IM nail group. The study observed no difference in time to successful union. Radiographically, no difference in femoral flexion, extension, or fracture translation, and an equal trend toward valgus alignment was observed [36]. In a small, retrospective study, Kiliçoğlu et al demonstrated no difference in the time to

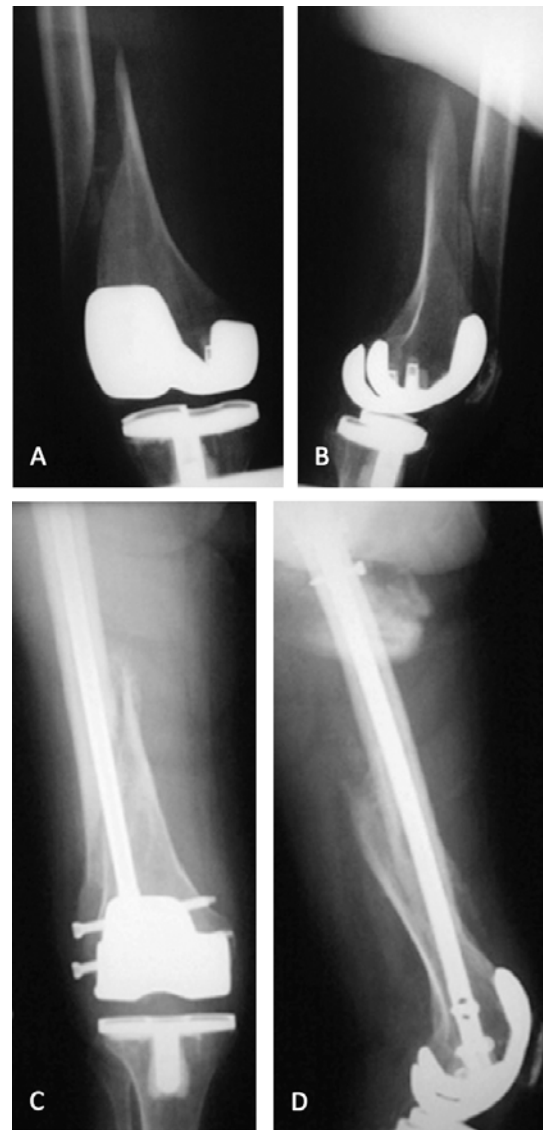


Figure 2. A, B, AP and lateral radiographs demonstrating a long, spiral PDFF with a stable femoral implant (Lewis and Rorabeck 2, Kim 1B). C D, Postoperative radiograph showing treatment with a retrograde, interlocking intramedullary nail and characteristic extension of the distal fragment due to the femoral component forcing the starting point posterior.

union, range of motion, Knee Society Score or sagittal and coronal alignment when retrograde IM nailing was compared with ORIF with locking plates [39].

Several limitations exist for this technically challenging surgical option. Insertion of a retrograde IM nail risks joint infection secondary to the necessary arthrotomy. Secondly, the size of the fracture fragments precludes use in severe comminution and should only be utilized for large distal fragments. Further, IM nailing cannot be used in patient's with a posterior stabilized total knee implants due to the closed intracondylar box [40]. IM nail fixation requires a diaphyseal fit for stability, thus long, proximally locked nails are required. The presence of an ipsilateral to-

tal hip arthroplasty creates a possible stress riser between implants and bridging may be required if this situation is present.

Revision Total Knee Arthroplasty

Revision TKA is indicated in patients with adequate bone stock, a simple fracture pattern without ligamentous instability, and a loose or malaligned femoral component [41]. This corresponds to a Rorabeck type 3 and a Kim type 2. Utilization of an uncemented long-stemmed femoral component with indicated fracture fixation using interfragmentary screws and small plates is preferred, as this construct allows for early weightbearing [42]. Preoperative walking ability, range of motion, and early post-op rehabilitation were the primary determinants of a good outcome in the Cordeiro et al study of revision TKA in 5 of 10 patients presenting with PDFF [43]. Srinivasan et al. reported on 6 PDFF and 2 complex native distal femur fractures treated with long-stem femoral components. The most common complication was a mean loss of 7.7 degrees of flexion; highlighting the importance of early mobilization in this group. Mean time to fracture union was 3.8 months [42].

Patients presenting with a PDFF about poor or deficient bone stock pose a challenge to the surgeon and two options exist for treatment: allograft-prosthetic composite (APC) or distal femoral replacement. These treatment methods may also be required for nonunion following previously failed attempt at fracture fixation via ORIF or IM nail fixation. Concern for early loosening of highly constrained implants in young, active patients may lead the surgeon to treatment with an APC. This involves the subperiosteal excision of the deficient distal femur while retaining the soft tissue sleeve of collateral ligaments and implantation of a stemmed, semi-constrained TKA. In a review of 9 patients treated with APC for PDFF, Kassab et al. noted union without migration or loosening at mean follow-up of 6 years [44]. In 68 patients treated with APC, 17 for PDFF, Backstein et al. reported one nonunion, two fractures through allograft, and four deep infections. They also noted a 14.8% revision rate at 5.4 years [45].

For low-demand patients or patients having failed previous fixation or reconstruction methods, revision with a distal femoral replacement (DFR) is an option. Although new implant designs give increased freedom of rotation, thus decreasing the bone-prosthesis stress, this should be seen as a limb salvage procedure. Berend and Lombardi reviewed 39 rotating-hinged DFR devices used a cohort of 37 patients, including 13 PDFF cases. There was no incidence of aseptic loosening at mean follow up of 46 months with 87% survivorship. There were five reoperations, including two patients with recurrent infection after two-stage treat-

ment, one patient with a periprosthetic fracture treated by open reduction and internal fixation, one patient with late hematogenous infection, and one patient with bearing exchange to treat hyperextension [46].

In a review of 22 PDFF in 20 patients with a mean age of 69.5 and 58.6 months follow up, Mortazavi et al. showed a high complication rate of 22.3% requiring additional surgery. One patient had refracture with subsequent nonunion, a second fracture between the stems of the DFR and THA, a third sustained a subtrochanteric fracture above the DFR stem, the fourth developed a femoral neck and intertrochanteric fracture of the ipsilateral hip 2 months after the index revision knee surgery, and the fifth patient developed a hematoma 10 days after surgery, which was drained in the operating room. He then presented with a fracture of femoral stem 34 months after the index revision surgery. The authors caution use of DFR as a last resort where alternative treatment options are not possible [47]. Figure 3 demonstrates the clinical course of this patient.



Figure 3. A, B, AP and lateral radiographs of a PDFF about an unstable femoral component in a patient with good bone stock (Lewis and Rorabeck 3, Kim 2). C, demonstrates distal femoral replacement stem fracture at 34 months post-op necessitating revision with distal femoral replacement, D. (From Mortazavi, et al, *J Arthroplasty* 2010; 25:775-780.)

Few comparison studies exist with matched cohorts, but Saidi et al. present 23 patients; 7 treated with APC, 9

patients received revision TKA systems (RSA), and 7 patients had DFR. Operative time and blood loss were significantly less in RSA and DFR and shortest average hospital stay (6.4 days) was in the DFR group. No difference was observed in the 6 week or 6 month Knee Society Scores [4]. These results highlight the possibility that low-demand patients can be successfully treated with DFR without an increased complication rate.

Complications

The associated morbidity and mortality of PDFF are very high and carry a greater risk than native distal femoral fractures [48]. Mortality of up to 17% at 6 months and 30% at 1 year have been reported [49,50,51]. Postoperative mobility of patients is of utmost importance and many patients will require long-term ambulatory assistance. Fracture union is often delayed in these patients and close follow up is required [6,29]. If nonunion is of specific concern due to host factors, indirect reduction techniques and sub muscular plating or DFR should be chosen [46,52]. Patient specific complications include extensor mechanism disruption, infection, and implant failure. Complications of prolonged immobility are respiratory tract infections, thromboembolism, pressure ulcers, mental status changes, and urinary tract infections.

Conclusions

PDFF present a challenge to the arthroplasty surgeon. The decision of ORIF versus revision arthroplasty should be made in the context of the patient's pre-injury physiologic and anatomic status. Early mobilization, early union, and respect for soft tissue integrity are paramount concerns. A suggested treatment algorithm based on the Rorabeck and Kim classifications and literature review is presented in figure 4.

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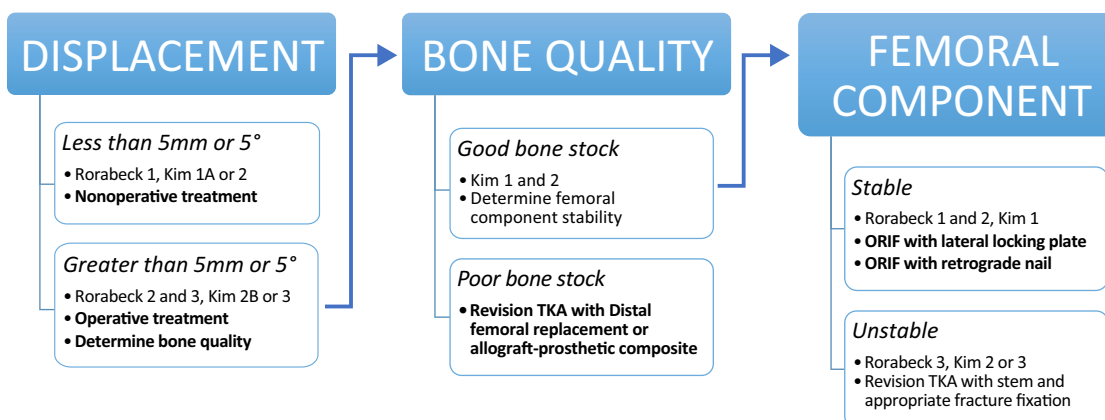


Figure 4. Treatment algorithm based on radiographic interpretation of fracture displacement, bone quality, and femoral prosthesis integrity.

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SUBMISSION HISTORY

Submitted June 23, 2017
 Reviewed August 21, 2017
 Revised October 25, 2017
 Accepted November 14, 2017
 Published December 31, 2017

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AUTHOR DISCLOSURES

The authors declare that there are no disclosures regarding the publication of this paper.

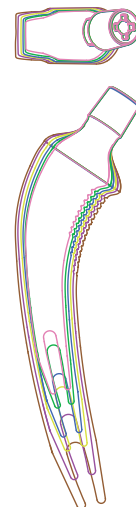
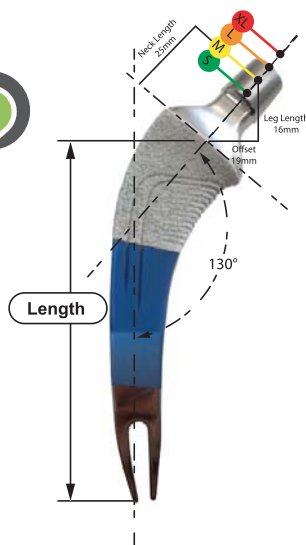
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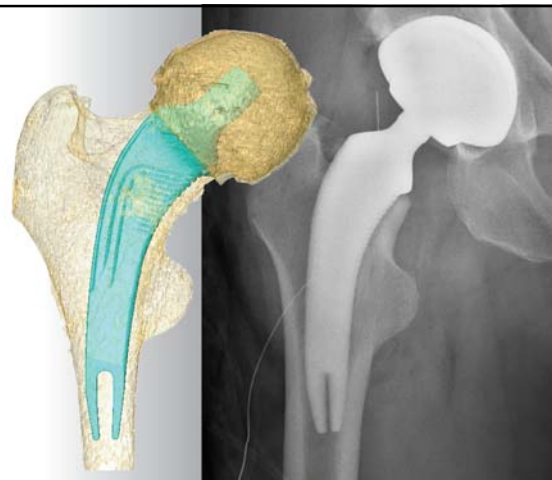
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Femoral Head-Trunnion Dissociation in Metal-on-Polyethylene Total Hip Arthroplasty – A Unique Case Report

Patel N¹, Guild G¹, Erens G¹

Abstract

Background: Gross trunnion failure (GTF) after total hip arthroplasty is a rare complication and has only been reported in a few case series. Some of the associated risk factors have been described in the literature and include larger femoral heads, greater offset, and increased BMI. Despite this, the mechanism behind GTF is poorly understood and early diagnosis and treatment continues to be challenging.

Case Presentation: We present the case of complete femoral head and trunnion dissociation in a 63 year-old female nine years after total hip arthroplasty. Unique to this case is the lack of classic patient and implant risk factors for GTF along with the acute onset nearly nine years after implantation.

Discussion: This case presentation highlights the fact that the contributing factors and mechanism behind GTF continue to be poorly understood. There is a need for future research to help better understand this phenomenon and to help potentially identify those at risk for GTF.

Background

The use of femoral head modularity with a trunnion and bore has been the gold standard in hip arthroplasty due to ease of use, leg length and offset adjustability, and improved exposure in revision settings. Despite frequent use of modular components, corrosion at the head-neck junction

or trunnionosis has only recently received increased attention [1]. Severe trunnion corrosion can lead to mechanical deformation of the trunnion resulting in gross trunnion failure (GTF) [2]. The specific implant and patient factors that contribute to trunnionosis and GTF continue to be poorly understood. Several implant specific characteristics have been reported including titanium-alloy modulus, trunnion volume and contact area, taper-angle mismatch, varus-neck angle, high-offset, larger head, and dissimilar metals [3]. Potential patient specific factors include high activity level, obesity, and male gender. [3]. Incomplete trunnion cleaning at time of surgery and inappropriate impaction force of the head-neck have also been described [4]. We describe a case of GTF in a patient without the classically reported risk factors.

Case Presentation

At initial presentation in 2007, the patient was a 55 year old female with BMI of 22.8 and past medical history consisting of lumbar radiculopathy. She reported a multiple year history of progressive left sided hip and groin pain and was found to have end stage left hip osteoarthritis on radiographs (Figure 1). After failure of conservative measures, the patient underwent elective left total hip arthroplasty in

Keywords: hip arthroplasty, trunnion failure
Level of Evidence: AAOS Therapeutic Level IV
Educational Value & Significance: JISRF Level B



Figure 1. Preoperative AP pelvis (A) and left hip frog leg lateral (B) radiographs from May 2007 demonstrating advanced osteoarthritis of the left hip.



Figure 2. Initial post-operative AP pelvis radiograph from October 2007 after left total hip arthroplasty. Implants include Accolade I size 2.5 femoral component with 127° neck angle, Trident 52mm E acetabular shell, 32mm +4 CoCr head ball, and X3 32mm, 0 degree polyethylene liner.

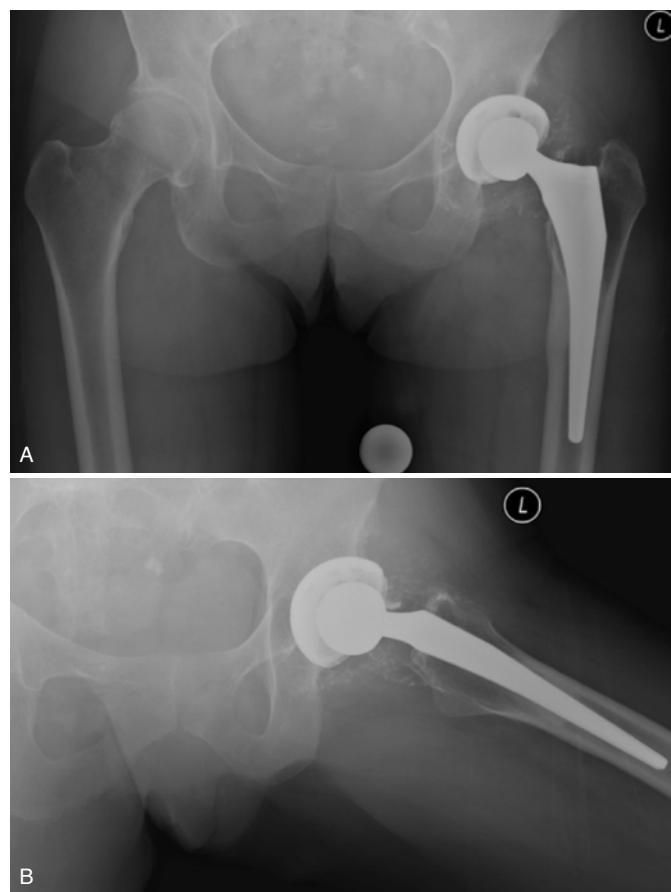


Figure 3. AP pelvis (A) and left hip frog leg lateral (B) radiographs taken in July 2016, almost 9 years after initial implantation. Best visualized on the AP view, there is now notable change in angulation at the head ball trunnion interface from prior imaging with the head ball now residing in a more varus conformation. Additionally, metallic debris can be visualized outlining the left hip capsule.

October 2007 and tolerated the procedure well. Her hip implants consisted of an Accolade I TMZF size 2.5 femoral component with 127° neck angle, Trident 52mm E acetabular shell, 32mm +4 cobalt-chrome (CoCr) head ball, and an X3 32mm, 0 degree crosslinked polyethylene liner (Stryker Mahwah, NJ) (Figure 2). She had an unremarkable post-operative course. The patient returned to clinic in 2016, almost nine years after her initial surgery, now 63 years old and with a BMI of 23.5. Her complaints included 3 weeks of painless clunking and left hip mechanical symptoms. Imaging revealed significant metallic debris about the hip joint along with interval alignment change at the head-trunnion interface with the head ball now residing in a more varus angulation (Figure 3). Based on these findings suggesting trunnion compromise, surgical intervention was felt warranted and revision hip surgery was scheduled. Several days after evaluation, the patient presented to the emergency room with acute onset of significantly worsened left hip pain and found to have complete dissociation of the femoral head and trunnion (Figure 4).



Figure 4. AP pelvis radiograph from August 2016 demonstrating complete femoral head ball and trunnion dissociation. Significant wear can be noted around the trunnion with again visualized metallic debris outlining the left hip capsule.

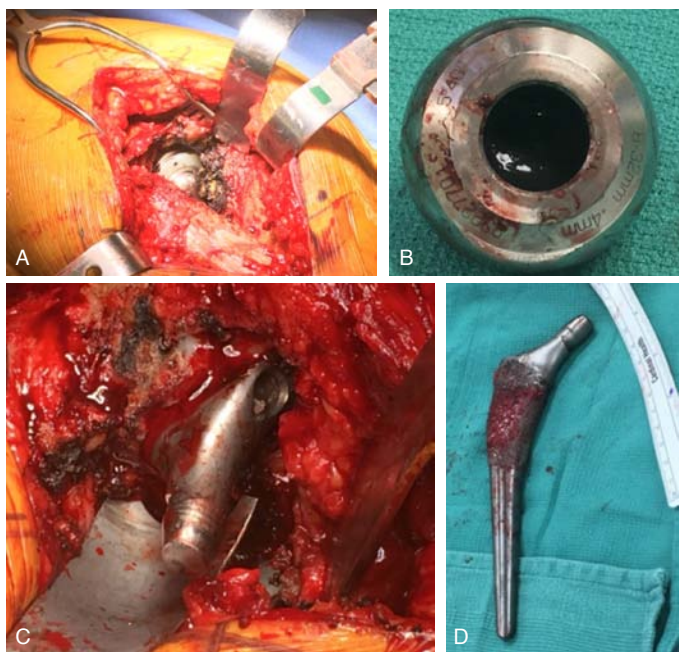


Figure 5. Intra-operative images from the revision left hip surgery in August 2016 (A) Posterior surgical approach to the left hip with obvious metallosis visualized in the soft tissues surrounding the implants. (B) 32mm with +4mm offset CoCr head ball with evidence of corrosion and metallic debris inside. (C) In vivo and (D) explanted Accolade I size 2.5 femoral stem with significant wear noted about the trunnion.

The patient was admitted and underwent revision left hip arthroplasty without complication. Intraoperative images from her revision surgery are shown in Figure 5. She was found to have extensive metallosis in the soft tissues surrounding the left hip along with advanced corrosion and loss of material at the femoral trunnion. Her femoral component was replaced with a long stem modular implant fitted with a 36mm ceramic head ball and her polyethylene



Figure 6. Post-operative AP pelvis radiograph after revision left total hip arthroplasty in August 2016. The patient's original femoral implant was replaced with a long stem modular component fitted with a 36mm ceramic head ball. The acetabular shell was left in place and fitted with a new 0 degree polyethylene liner.

liner was exchanged (Figure 6). Plasma chromium level was 10.0 µg/L (Ref range 0.1 – 2.1) and serum cobalt level was 20.9 µg/L (ref range 0.0 – 0.9). Since the revision surgery, the patient has done well with minimal hip pain and good mobility.

Discussion

Despite an increasing body of literature on trunnionosis, there has been little reported on the unique mechanism of GTF. The few previous small case series have attempted to describe patient, implant, and surgeon factors that may contribute. In a series of five GTF's with the Accolade I TMZF stem (Stryker, Mahwah, NJ), Matsen et al. noted that male sex, BMI > 30, head size 36mm or greater, lateral offset (127°) neck angle, and increased head offset were commonly associated factors [5].

In a case series involving multiple manufacturers, Banerjee et al. discuss the lack of data to implicate one single taper or neck geometry [2]. They too note the association with male gender and increased femoral offset. They surmised that the increased offset in the head may lead to stress and micro-motion in the taper with eventual fatigue and gross failure.

Confounding the issue have been reports of abnormal reactions to Beta titanium (TMZF) and concerns over its decreased modulus of elasticity being able to withstand cyclic loading. In a paper by Kirin et al., the authors postulate that the impaction of the femoral head or cyclic loading removes the oxide passivation layer creating crevices in the taper junction [6]. This allows for fluid ingress within the

taper with depletion of oxygen and ionic changes ultimately leading to the formation of hydrochloric acid and resulting corrosion. It is possible that the decreased flexural rigidity of the TMZF trunnion contributes to crevice corrosion, as trunnions with higher modulus of elasticity have been shown to have less crevice corrosion [7]. Further confounders exist as there are studies that both support and refute the concept of taper size and geometry being associated with corrosion [8,9]. In a retrieval analysis, Cook et al. suggest that a combination of taper and trunnion angle mismatch, the use of a proximal contacting taper, and coupling of dissimilar metal alloys leads to taper damage and material loss [10].

Subsequent to the above mentioned reports, Stryker Orthopaedics (Mahwah, NJ) issued a class II recall of 42,519 Co-Cr V40 LFIT head balls on August 29, 2016. Stryker received several complaints describing incidence of harm secondary to taper lock failure for specific lots of LFIT Anatomic CoCr V40 Femoral Heads thought to be a result of improper manufacturing tolerances. The patient in this case did not have a recalled implant.

What makes GTF evening more challenging to identify is the substantial time typically seen from implantation to failure. Walker et al. noted time to gross failure ranging from 4.4 to 7.6 years in a case series consisting of four patients [11]. Similarly, the time to trunnion failure observed in the presented case was nearly nine years after initial implantation.

This patient's demographics and implant characteristics are not typical of what has been reported in the literature with GTF and underscores the fact that the mechanism of femoral head-neck dissociation is still poorly understood. The patient in this case is female, with a BMI of 23.5 and an implantation time of nine years as compared to most other reports of male patients with BMI > 30. This demonstrates that gender and BMI may be patient specific risk factors, but are not predictive of corrosion or failure. From an implant standpoint, the patient had a 32mm femoral head, not the typical 36mm or greater femoral head sizes suggested by previous authors as risk factors. The neck angle in this case is 127° (varus neck) with an increased offset head (+4) on a Beta titanium stem with greater flexibility. These circumstances highlight that the cause of GTF may be multifactorial, but micromotion at the head-neck may be the common denominator. It remains difficult to suggest which patients should be monitored with x-rays, serum ion levels, and cross sectional imaging across all manufacturers. However, it is reasonable to identify patients who received recalled implants and provide surveillance with potential to intervene before GTF occurs. The typical lack of symptoms prior to GTF makes early diag-

nosis and treatment challenging, and a high index of suspicion is required for early intervention. Future research is clearly needed to better understand this phenomenon and to help further identify those who are at risk for corrosion and GTF.

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SUBMISSION HISTORY

Submitted September 9, 2017
Reviewed October 1, 2017
Revised December 6, 2017
Accepted December 7, 2017
Published December 29, 2017

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AUTHOR DISCLOSURES

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Search Engine Optimization for Medical Publishing

Faroo D¹

Abstract

Search engine optimization is becoming increasingly important for medical publishing professionals. They know the value of writing papers and articles that help expand the knowledge of their specific area of expertise. They also know that in today's online environment their publications need to be found in relevant web searches to be cited by fellow researchers. But if authors ignore the basics of keyword research and search engine optimization they run the risk of their research being lost in a vast sea of search results. What good is all that work if it never reaches the intended audience? The purpose of this commentary is to provide submitting authors basic yet important suggestions to help optimize their articles for online publishing with Reconstructive Review.

Background

An eruption occurred during the second half of the 20th century that today has turned into an explosion of data and information. It's called the "internet." There it is, that one-word invention (sorry Al Gore, not yours) that pervades our lives to the point where it's hard to imagine life without it – growing so fast that it's quickly becoming our main source of information and communication. This is true for all facets of our society, government, and industry, and medical publishing is certainly no exception.

Now that the world's data is literally at our fingertips it's more important than ever for authors to optimize digital content for relevant web searches. The concept of search optimization began in 1945 when Dr. Vannevar Bush wrote

about creating a common archive for all the world's data. He published an article in The Atlantic proposing a "collection of data and observations, the extraction of parallel material from the existing record, and the final insertion of new material into the general body of the common record." [1] It wasn't until the 1990s (20 years, or so, after the dawn of the internet) that the idea spawned the development of the search engines that we know today. [2]

The number and nature of search engines on the internet is almost as overwhelming as the amount of information available. There are academic search engines like PubMed, Scopus, and Google Scholar as well as commercial ones like Google, Bing, and Yahoo. While differences exist between commercial, academic, and other types of search engines, they all do basically the same thing – using various "algorithms" to deliver the most relevant content to the top of the search results. Google by far is the biggest search engine with up to 77% of global searches. [3] It may not traditionally be used for academic research but it does return results from academic sites like PubMed and PubMed Central. So how does an author stand any chance of their work being found in this expanding sea of data?

It Starts with the Keywords

What are keywords and how many do I need? "Keywords are ideas and topics that define what your content is about. ...they are the words and phrases that searchers enter

Keywords: search engine optimization, medical publishing, keyword research

Educational Value & Significance: JISRF Level B

into search engines, also called ‘search queries.’ If you boil everything on your page – all the images, video, copy, etc. – down to ... simple words and phrases, those are your primary keywords.” [4] The tendency is to come up with too many keywords. Try to limit the number of words and phrases. While there is no perfect number, having dozens of them makes it impossible to effectively optimize one document.

Most online journals require authors to provide a list of keywords during the submission process. Many authors determine those keywords only after their article has been written – listing the most important keywords as an afterthought. There are specific tools online to help authors create a list of keywords based on what has been written. However, it would be better if authors spend a few minutes doing some simple keyword research before writing begins.

This research can turn up keywords (or terminologies) that have not been considered, even ones equally or more relevant to the subject matter. It may even reveal the misuse (or misspelling) of specific terms. In the March 2017 issue of Reconstructive Review Professor Panayot Tanchev of the Medical University of Sofia in Bulgaria commented on the correct use of terminology. “Medical terminology is an important tool for communication among medical practitioners, researchers, and scientists. The precise use of terms ensures a successful orientation in the field of medical practice contributing to the adequate treatment of patients.” [5] While his comments were specifically about the use of “osteoarthritis” vs. “osteoarthrosis” the same precise use of terms is equally true for search optimization. If your article is targeting the wrong keywords, or even worse, misused or misspelled terms, it will be difficult for fellow researchers to find.

Do Some Quick Research

There are many ways to research keywords online and a great deal of time can be spent wandering down this rabbit hole. The easiest way to start is to search the internet as a researcher would looking for your work. Look at the results to make sure they are relevant to the subject of your article. If they are, then the words you used in the search will be important keywords. Keep an eye out for words or phrases that you haven’t considered. Also be aware of the “predictions” that search engines provide as you are typing in your search (Figure 1). They provide alternative search words and phrases that are relevant to what is being searched and may need to be included in your own list of keywords.

Reconstructive Review joins most online medical journals in recommending that authors use Medical Subject Headings (MeSH) to find keywords. “MeSH is the Nation-

Google Scholar

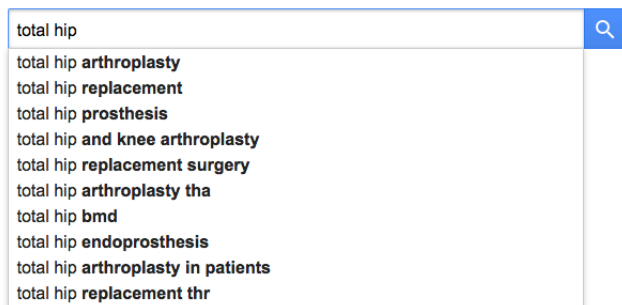


Figure 1. Screen capture of a Google Scholar search. Most search engines make predictions of what is being searched, providing alternative search words and phrases.

al Library of Medicine’s controlled vocabulary thesaurus. It consists of sets of terms naming descriptors in a hierarchical structure that permits searching at various levels of specificity. MeSH descriptors are arranged in both an alphabetic and a hierarchical structure.” [6] MeSH offers a couple of ways to find descriptors to use as keywords. MeSH on Demand is a tool that allows authors to input text from an abstract to automatically identify related MeSH terms. The MeSH browser is another tool that enables a direct search for related terms and descriptors using an existing list of keywords. For a complete description of the use of these tools visit the page titled “Suggestions for Finding Author Keywords using MeSH Tools” [7] on the National Library of Medicine’s website.

Make the Best Use of Keywords

Once a list of keywords has been created put them in order of importance. Make sure to use the most important keyword, or words, at the beginning of the title and the abstract. Also be sure to use all of your keywords in the abstract because many online journals only display the title and abstract keeping the full text behind a login or a purchase point. While Reconstructive Review is open access and does not require a login or charge a fee to see the full text, the primary link to each article points to a summary page that contains the title, authors, abstract, keywords, list of references, and links to the full text in both PDF and HTML. So the first few keywords on the list should be used the most throughout the entire article and all keywords should be used in the title and abstract. Although it is important to use all your keywords throughout your article don’t repeat them so much that it annoys your readers.

Finally, the importance of search optimization in medical publishing is only going to increase as the internet continues

to grow – aggregating more and more of the world’s data, increasing search competition and making it more difficult for published articles to be found. Temper your search optimization expectations with the following questions. Does your article add to the ongoing online conversation discussing the subject matter of your article? Is it unique? If so, make sure to highlight this in your list of keywords and in your writing. Articles with unique content should jump right to the top of search results. Whether or not your article faces stiff search competition don’t forget to promote your work by linking to it from social media sites like Facebook, LinkedIn, ResearchGate, and Twitter, as well as any other personal or institutional websites. While these suggestions are relatively basic to the practice of search engine optimization for medical publishing they should not be overlooked if authors want any chance of their articles being discovered online.

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SUBMISSION HISTORY

Submitted December 6, 2017
Reviewed December 7, 2017
Revised December 19, 2017
Accepted December 28, 2017
Published December 31, 2017

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AUTHOR DISCLOSURES

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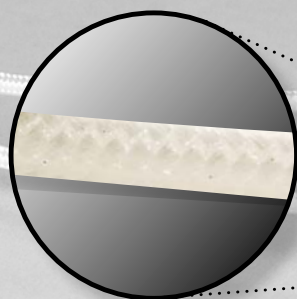
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Levels of Evidence

Reconstructive Review has adopted the American Academy of Orthopaedic Surgeons (AAOS) Levels of Evidence for Primary Research Question. These guidelines will now be part of the review process for manuscript submission.

	Types of Studies			
	Therapeutic Studies – Investigating the results of treatment	Prognostic Studies – Investigating the effect of a patient characteristic on the outcome of disease	Diagnostic Studies – Investigating a diagnostic test	Economic and Decision Analyses – Developing an economic or decision model
Level I	<ul style="list-style-type: none"> • High quality randomized trial with statistically significant difference or no statistically significant difference but narrow confidence intervals • Systematic Review² of Level I RCTs (and study results were homogenous³) 	<ul style="list-style-type: none"> • High quality prospective study⁴ (all patients were enrolled at the same point in their disease with $\geq 80\%$ follow-up of enrolled patients) • Systematic review² of Level I studies 	<ul style="list-style-type: none"> • Testing of previously developed diagnostic criteria on consecutive patients (with universally applied reference “gold” standard) • Systematic review² of Level I studies 	<ul style="list-style-type: none"> • Sensible costs and alternatives; values obtained from many studies; with multiway sensitivity analyses • Systematic review² of Level I studies
Level II	<ul style="list-style-type: none"> • Lesser quality RCT (e.g. < 80% follow-up, no blinding, or improper randomization) • Prospective⁴ comparative study⁵ • Systematic review² of Level II studies or Level I studies with inconsistent results 	<ul style="list-style-type: none"> • Retrospective⁶ study • Untreated controls from an RCT • Lesser quality prospective study (e.g. patients enrolled at different points in their disease or <80% follow-up.) • Systematic review² of Level II studies 	<ul style="list-style-type: none"> • Development of diagnostic criteria on consecutive patients (with universally applied reference “gold” standard) • Systematic review² of Level II studies 	<ul style="list-style-type: none"> • Sensible costs and alternatives; values obtained from limited studies; with multiway sensitivity analyses • Systematic review² of Level II studies
Level III	<ul style="list-style-type: none"> • Case control study⁷ • Retrospective⁶ comparative study⁵ • Systematic review² of Level III studies 	<ul style="list-style-type: none"> • Case control study⁷ 	<ul style="list-style-type: none"> • Study of non-consecutive patients; without consistently applied reference “gold” standard • Systematic review² of Level III studies 	<ul style="list-style-type: none"> • Analyses based on limited alternatives and costs; and poor estimates • Systematic review² of Level III studies
Level IV	Case Series ⁸	Case series	<ul style="list-style-type: none"> • Case-control study • Poor reference standard 	<ul style="list-style-type: none"> • Analyses with no sensitivity analyses
Level V	Expert Opinion	Expert Opinion	Expert Opinion	Expert Opinion

1. A complete assessment of quality of individual studies requires critical appraisal of all aspects of the study design.
2. A combination of results from two or more prior studies.
3. Studies provided consistent results.
4. Study was started before the first patient enrolled.
5. Patients treated one way (e.g. cemented hip arthroplasty) compared with a group of patients treated in another way (e.g. uncemented hip arthroplasty) at the same institution.
6. The study was started after the first patient enrolled.
7. Patients identified for the study based on their outcome, called “cases”; e.g. failed total arthroplasty, are compared to those who did not have outcome, called “controls”; e.g. successful total hip arthroplasty.
8. Patients treated one way with no comparison group of patients treated in another way.

Educational Value & Significance

JISRF has established a guideline as to the level of Educational Value & Significance. This will now become part of the Peer Review process with the following rating system:

JISRF Levels of Educational Value & Significance

A = Novel and extremely significant for all.

B = Novel and significant for many.

C = Novel and interesting for limited readership.

D = Novel and mild interest to readership.

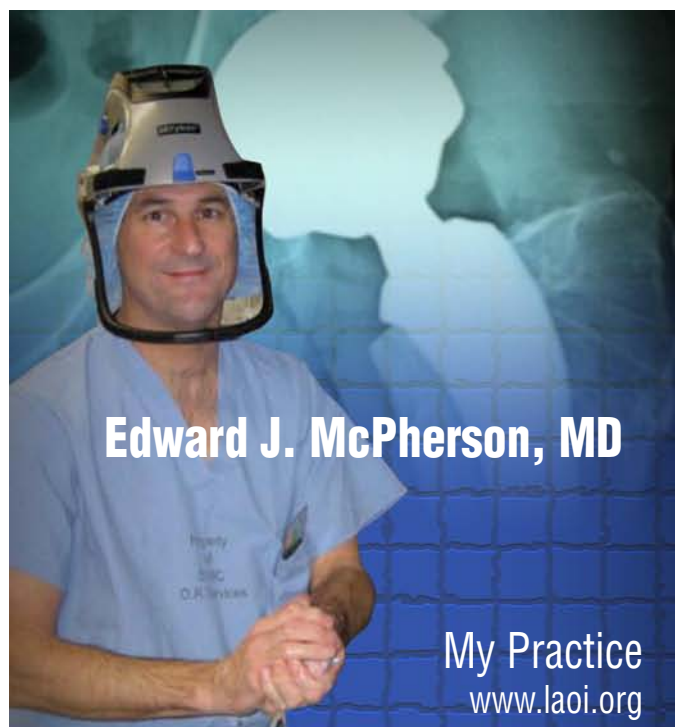
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Since 1948, the Greenbrier Clinic has been recognized as an industry leader in executive health and wellness through utilizing advanced diagnostics in the early diagnosis, prevention and treatment of disease. Building upon that history of medical excellence, Jim Justice, Chairman and owner of the Greenbrier Resort, has announced the creation of the Greenbrier Medical Institute. The institute's 1st phase is projected to cost about \$250 million, employ more than 500 people and include 3 buildings.

This phase will include an expansion of our world renowned executive health and wellness practice, The Greenbrier Clinic, which will be bolstered by a world-class sports medicine program, including an orthopedic surgery center and athletic performance/rehabilitation facility, all led by the Founder of the American Sports Medicine Institute, Dr. Jim Andrews and Chair of Cleveland Clinic Innovations, Thomas Graham. Rounding out the Institute's services will be a first-



in-class plastic and cosmetic surgery and Lifestyle Enhancement Academy, helping people look and feel their best. Physicians, universities, research foundations, medical journals and other healthcare industry leaders, all of whom are on the cutting edge of medical technology, research and care, have committed to join the project and establish an international research and education destination or "think tank" to stimulate research, drive innovation, force change and redefine how the world approaches health, wellness and longevity.

The Institute's facility, designed by Willie Stokes, will feature Georgian architecture similar to the resort's façade, a replica of the Springhouse, the site of the famous sulphur springs and special guests suites for patients and their families. Jack Diamond, President and CEO, and Mark Krohn, COO, are leading the development of this exciting project and are actively looking for other physicians and medical thought leaders to be involved.

For more information, please contact:

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