An Updated Review on Layered Closure Techniques for Total Hip Arthroplasty

Nipun Sodhi, MD[1]
Orthopaedic Resident

Zhongming Chen, MD[2]
Research Fellow

Luke J. Garbarino, MD[3]
Orthopaedic Fellow

Sandeep S. Bains, MD, DC[2]
Research Fellow

Michael A. Mont, MD[2]
Director of Clinical Trials

[1]Department of Orthopaedic Surgery, Long Island Jewish Medical Center, North Shore University Hospital Northwell Health, New York, New York
[2]Center for Joint Preservation and Replacement, Sinai Hospital of Baltimore, Rubin Institute for Advanced Orthopedics, Baltimore, Maryland
[3]Department of Orthopaedic Surgery, Wake Forest School of Medicine, Winston-Salem, North Carolina

ABSTRACT

Introduction: One of the main concerns with total hip arthroplasty is the development of periprosthetic joint infections (PJIs). Appropriate wound closure can contribute to the prevention of PJIs with a watertight closure effectively sealing the implant from the outside. It is important to continuously investigate which materials as well as techniques are potentially the most efficacious and cost effective for wound closure. Therefore, the purpose of this review article was to critically appraise the current total hip arthroplasty wound closure materials and techniques as reported in the literature. Specifically, we evaluated: 1) fascial approximations; 2) subdermal closures; 3) subcuticular and skin closures; 4) wound dressings; as well as 5) capsular and short external rotator repairs.

Materials and Methods: A literature search was performed using the PubMed database from inception to February 2022. The query consisted of terms including "hip, arthroplasty, wound, closure, capsular closure, fascial closure, subcutaneous closure, and skin closure." References from selected texts were also reviewed for inclusion. Only manuscripts written in the English language were included for final analysis. A systematic review was performed for the five topics: 1) fascial approximations; 2) subdermal closures; 3) subcuticular and skin closures; 4) wound dressings; as well as 5) capsular and short external rotator repairs. Additionally, a meta-analysis was performed on the closing time of fascial approximations.

Results: The current literature supports performing a layered closure of the wound by approximating the fascial layers, which can help close any empty spaces. The techniques for closure at this layer seem to be equal regarding

wound complications between running knotless barbed sutures versus interrupted throws; however, knotless sutures have the potential of a quicker closure time. A total of three out of four reports and the meta-analyses demonstrated that wound closure time can be reduced with barbed sutures, along with decreased number of sutures required as also shown by three out of four reports. The most superficial layers, subcuticular and skin, can be closed with either sutures, staples, or skin adhesives, all of which appear to have adequate outcomes. A report found that patients who had skin closure with barbed suture had faster time to a dry postoperative wound and lower rates of delayed discharge. For the overlying dressing, an occlusive and absorbent dressing can both protect the wound as well as collect any residual wound drainage. Two reports found increased dryness, decreased wound drainage, and decreased rates of delayed wound healing with use of 2-octyl cyanoacrylate topical adhesive with flexible self-adhesive polyester mesh dressings. If the capsule and short external rotators are taken down during the approach, repairing these can potentially help increase postoperative hip stability as well as decrease dislocation rates.

Conclusion: The variety of materials and techniques available to close a THA wound allows surgeons to tailor closure to be patient specific. In general, the authors recommend performing layered closures from the capsule and short external rotators (if taken down during the approach), fascial layer closure with either a running knotless suture, subcutaneous closure either with the same knotless suture as the fascial layer brought more superficially, or with simple interrupted sutures to tack down any empty space, as well as finally subcuticular and skin sutures with a skin adhesive glue overtop. The skin adhesive can help provide an extra layer, particularly in active patients.

INTRODUCTION

Periprosthetic joint infections (PJIs) are one of the biggest postoperative concerns following total hip arthroplasty (THA).[1] One of the most agreed upon PJI prevention strategies is adequate wound closure; if an aseptic seal can be formed around the implant, the chances of septic material infiltrating the prosthesis are lowered.[2–4] Nevertheless, the approach to wound closure can vary greatly among surgeons. Currently, there is an abundance of literature regarding different wound closure materials and techniques. These include, but are not limited to, running versus interrupted sutures, barbed versus braided versus monofilament sutures, staples, and skin glues.[5,6] While all of these materials have the potential to help bring tissues together long enough to allow for biologic healing, it is important to continuously investigate which materials and techniques are potentially more efficacious as well as cost effective. Therefore, the purpose of this review article was to describe and critically appraise the current total hip arthroplasty wound closure materials and techniques as reported in the literature. Specifically, we evaluated: 1) fascial approximation; 2) subdermal closure; 3) subcuticular and skin closure; 4) wound dressings; as well as 5) capsular and short external rotator repair.

MATERIALS AND METHODS

A literature search was performed using the PubMed database from inception to February 2022. Searches were conducted using the following terms: hip [title], arthroplasty [title], wound closure [title], capsule closure [title], closure technique [title], suture [title], deep [title], fascia [title], subcutaneous [title], skin [title], subcuticular [title], barbed suture [title], staple [title], adhesive [title], and dressing [title]. Additional search terms included "total hip replacement" and "wound closure review." Additionally, the references from selected texts were also reviewed for supplemental sources of data.

We evaluated English reports, studies with greater than 20 patients, and investigations where outcome data were available as well as not replicative of previous examinations. Reports in foreign languages were excluded. In addition, higher-quality studies, Level of Evidence I and II, were preferentially included for analysis; however, as needed, studies of lower quality were utilized.

After our initial search resulted in 199 results, review of the Title and Abstract of each of the published works yielded 52 studies to be included for final analysis (Fig. 1).

Data analyses

All studies, such as fascial approximation closing times, were compiled and tabulated using Microsoft Excel® (Microsoft Corporation, Redmond, Washington) for systematic review. Meta-analysis statistics and generation of forest plots were performed with

Review Manager (RevMan™, Windows, version 5.3, Cochrane Collaboration, 2020; Microsoft Corporation, Redmond, Washington).

RESULTS

Description of fascial approximation

The fascial closure is arguably one of the most important layers to close, as this layer provides stability support to the joint, as well as creates a watertight seal around the joint to maintain an aseptic environment. Surgeons have used various techniques to close these layers, such as interrupted continuous sutures and, more recently, barbed sutures.[7–19]

Review of fascial closure articles

Ting et al. performed a single blinded, prospective randomized trial on the use of knotless suture closure in total joint arthroplasty patients.[18] The authors utilized a standard posterior approach with capsular repair. In their traditional closure cohort, the deep fascia was repaired with interrupted #1 braided absorbable sutures, the subcutaneous fat closed with simple interrupted throws with #0 braided absorbable sutures, and the subdermal layer closed with #2-0 monofilament absorbable suture with inverted interrupted knots. A skin adhesive was then placed over the incision as well as staples. In the knotless cohort, a similar 3-layer closure was performed, but with barbed equivalents: a barbed number 2 polydioxanone (PDO) deep, a barbed number 0 PDO in the intermediate layer, and a barbed 2-0 monoderm in the subdermal layer. The authors found for the barbed cohort, the overall closure time to be significantly shorter (9.6 vs. 15.0 minutes, $p=0.0218$) as well as fewer sutures to be used (2.6 vs. 6.5, $p<0.0001$). In their subset of THA patients, one patient developed peri-incisional erythema, which was resolved with oral antibiotics. The authors also noted that while suture costs were greater for the barbed cohort, the cost savings from the decreased closure time outweighed the higher suture prices.

Li et al. performed a comparative cohort study evaluating patients who underwent bilateral total joint arthroplasty and were randomized to barbed closure on one side and traditional closure on the contralateral side.[16] A posterolateral approach to the hip was utilized for exposure. In the barbed group, a running knotless #2 Quill™ (Henry Schein, Melville, New York) was utilized for the hip fascia and then was continued to run more superficial toward the middle of the deep fat layer. A #2-0 Vicryl® (Johnson & Johnson, New Brunswick, New Jersey) for two or three interrupted sutures were used to further approximate the tissue. Next, #2-0 Vicryl® was used to close the subcutaneous as well as superficial fat layers, and staples were used to approximate the skin. In traditional closure cohort, #1 Vicryl® was utilized to close the fascia, #2-0 Vicryl® for the fat as well as subcutaneous layers, and staples for the skin. The authors found significantly shorter closure times for the fascia (4.86 vs. 9.06 minutes, $p<0.001$) and overall wound (12.00 vs. 18.25 minutes, $p<0.001$) for the barbed suture cohort. In terms of complications, both cohorts had similar outcomes ($p=1$). Looking at costs, the authors also noted higher suture costs with the barbed sutures.

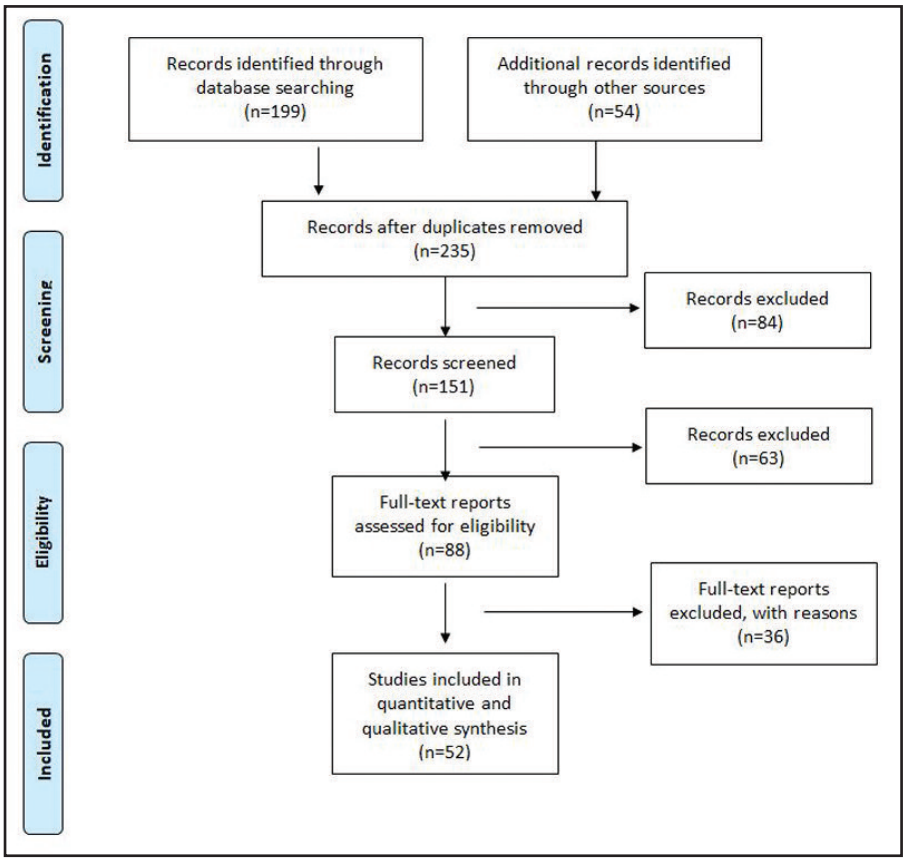

Figure 1. PRISMA diagram for study selection.

Sundaram et al. evaluated 60 patients undergoing a total of 60 THAs in a single blinded randomized trial.[13] The arthrotomy was closed either with barbed sutures (n=30) or with interrupted sutures (n=30). The group found closure duration to be significantly shorter in the barbed suture group (3 minutes ± 9 seconds vs. 8 minutes ± 26 seconds, $p<0.001$). Suture utilization was also less in the barbed suture closure cohort (one suture in 28 out of 30 [93%] patients vs. two to four sutures in 27 out of 30 [90%], $p<0.001$). Wound-related complications were similar in both cohorts (3 vs. 3%, $p=1.00$).

Lee et al. recently assessed 324 cases in which either barbed or interrupted suture techniques were utilized to close the fascia for 274 patients who underwent a THA through a posterolateral approach.[19] The surgeons closed every case in the same manner, except for the fascial layer, which was closed with either knotless barbed suture (n=126) or interrupted suture (n=198). The authors found that closure time with barbed sutures was significantly lower (difference of 5.8 minutes, $p<0.01$), compared to that for interrupted sutures. Additionally, the mean number of sutures required was 2.2 lower in the barbed cohort than the interrupted cohort ($p<0.01$). Furthermore, there were no increases in postoperative wound complications, despite the shortened closure times.

Table I
Studies highlighting fascial closure techniques

Author	Closure strategy 1	Closure strategy 2	Closure time (1 vs. 2, minutes)	p-value	#Sutures utilized (1 vs. 2)	p-value
Ting et al.[18]	Barbed suture	Braided/absorbable	9.6 vs. 15.0	p=0.0218	3 vs. 7	p<0.0001
Li et al.[16]	Barbed suture	Braided/absorbable	Fascia: 4.86 vs. 9.06 Overall: 12.00 vs. 18.25	p<0.001		X
Sundaram et al.[13]	Barbed suture	Braided/absorbable	3 vs. 8	p<0.001	One suture in 93% vs. two to four sutures in 90%	p<0.001
Lee et al. [19]	Barbed suture	Braided/absorbable	46.5 vs. 52.3	p<0.01	3.1 vs. 5.3	p<0.01

Summary of review articles (Table I)

A meta-analysis was conducted in an attempt to better elucidate differences between fascial closing times of barbed versus braided absorbable sutures. It included four studies and demonstrated overall shorter fascial closing times with the use of barbed sutures (Fig. 2).

Wound complication rates appear to be similar between barbed suture closure and more traditional simple interrupted sutures. However, the cost of the sutures is certainly a major consideration as they have been shown to be more expensive than non-barbed sutures. Yet, in the appropriate setting, overall wound closure time can be reduced with barbed sutures as demonstrated by three out of four reports and the meta-analyses, which can potentially, along with decreased number of sutures required as also shown by three out of four reports, result in an overall net savings.

Subdermal closure description and studies

With the subdermal layer in particular, a major goal is to decrease the amount of dead space, helping prevent hematoma or seroma formation, both of which can be a nidus for infection. Another advantage of closing this space is to help approximate the tissues and relieve suture stress on more superficial layers, allowing for a more aesthetic closure. Surgeons often use sutures to close this space, with some using traditional interrupted, while others use barbed sutures. However, there have not been any specific studies on closure of this layer alone.

Subcuticular and skin closure description

The final layers of closure include the subcuticular and skin closure. While these layers are not typically considered strength layers, they are critical to wound closure for two main reasons: 1) a watertight skin closure is arguably the best way to help prevent infection as a tight closure can prevent any contamination from the outside world, and 2) the skin closure is the final wound the patients can see, requiring the need to be aesthetic. A variety of different skin closure techniques have been reported in the literature, such as staples, traditional sutures, barbed sutures, and adhesives.[20–35]

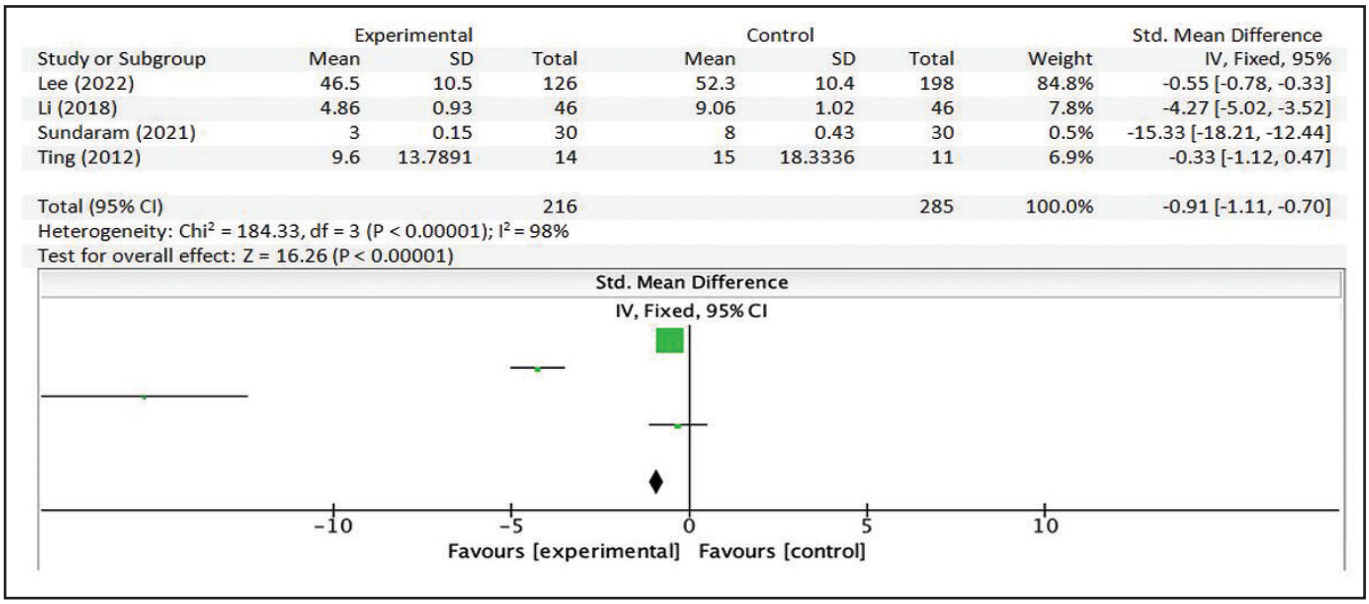

Figure 2. Forest plot with zoomed in insert for fascial closing times, barbed versus braided absorbable sutures.

Review of subcuticular and skin closure articles

Staples versus sutures

Rui et al. compared outcomes of 165 patients who underwent THA through a posterolateral approach and were randomized to have skin closure by interrupted sutures plus staples versus running 4-0 absorbable subcuticular suture.[26] The authors found no infections in the suture cohort, but two infections (2.4%) in the staples cohort. The time to a dry wound was also shorter in the suture cohort (4.8 vs. 5.0 days, $p=0.028$). Closure time was significantly faster with staples than with sutures (24.7 vs. 357.7 seconds, $p<0.001$). Additionally, there were no differences in patient satisfaction between the two cohorts.

Barbed sutures

Knapper et al. performed a prospective nonrandomized comparison between patients who underwent skin closure with barbed sutures (n=35) or with staples (n=53).[35] All patients underwent THA through a posterior approach with otherwise similar closure techniques except for skin closure. The group found that patients who had skin closure with barbed suture had significantly faster time to a dry postoperative wound ($p<0.0001$), and that for the staples cohort, ongoing wound drainage resulted in 6% of patients having a delayed discharge.

Adhesives

Parikh et al. performed a cross-sectional survey study to evaluate patient wound closure preferences following total joint arthroplasty.[34] Patients were given the choices between surgical staples or below-the-skin sutures with adhesive on top. The risks and benefits of both closure techniques were explained to all patients. Overall, the majority of patients chose sutures with adhesive over staples (151 vs. 12 patients). Specific to total hip arthroplasty, only three patients chose staples (25%) versus 60 patients who chose sutures with adhesive (40%).

Wang et al. performed a prospective study on 120 patients who underwent total hip arthroplasty through the posterolateral approach.[33] Patients were equally divided into three cohorts; group A: octyl-2-cyanoacrylate tissue adhesive alone, group B: tissue adhesive after continuous 3.0 subcuticular absorbable poliglecaprone suture, and group C: skin staples. Besides the subcuticular/skin closures, all deeper layers of closure were performed in a similar fashion for all three cohorts. The authors noted no significant differences ($p>0.05$) in terms of drainage, visual analog scale (VAS) score on the third postoperative day, or wound complications between the three cohorts. Time of closure differed, with staples (group C) being the fastest, then skin adhesive alone (group A), followed by skin adhesive plus sutures (group A). Overall, the authors conclude that closing skin with tissue adhesive alone (no additional sutures) is safe in THA.

Summary of subcuticular and skin closure

Liu et al. recently performed a meta-analysis and systematic review on staples versus sutures for skin closure in total hip arthroplasty.[32] The authors included five randomized control trials and one retrospective cohort study in their final analysis. The authors found 20 out of 627 (3%) of the staple cohort and six out of 659 (0.9%) in the suture cohort had superficial infections (odds ratio [OR]: 2.88, 95% confidence interval [CI]: 1.27 to 6.54; $p=0.01$). Looking at deep infections, seven out of 491 patients (1.4%) in the staple group, and four out of 527 patients (0.8%) in the suture group were infected (OR: 1.70, 95% CI: 0.56 to 5.21; $p=0.35$). Wound closure time was noted to be faster for staples than with sutures. The authors also noted patients had similar outcome scores when evaluating their skin wounds.

The current literature seems to support the common practices of subcuticular and/or skin closure techniques. Staples appear to the quickest way to close a wound but may be associated with a longer duration of drainage. One report found that patients who had skin closure with barbed suture had faster time to a dry postoperative wound and lower rates of delayed discharge. A combination of sutures and skin adhesive or skin adhesive alone also appears to be a reasonable option with moderate costs and closing time. Therefore, barbed sutures and adhesives are good skin closure options for total hip arthroplasties. Notably, patient satisfaction of their wounds was found to be similar regardless of closure type; however, these studies primarily utilized the posterior or postero-lateral approach, so the wound is not as evident in a patient's direct field of view. It is possible that for patients who undergo THA through an anterior approach, the satisfaction results could be different as the wound is more in line of sight.

Wound dressing description

The final step to overall wound closure is the dressing. A clean, dry, and sterile dressing helps protect the wound from any outside factors that might cause skin irritation, breakdown, drainage, or worst case, infection. There are a number of different dressing options including surgical adhesive, antimicrobial as well as non-antimicrobial impregnated materials, to simple gauze and tape. There are a few studies that have compared the various dressing types.[36–39]

Review of wound dressing articles

Traditional dressings

Harle et al. performed a randomized control trial wherein patients who underwent total hip arthroplasty were randomized to receive a modern AQUACEL® Hydrofiber® dressing (Convatec Group, Reading, United Kingdom; n=50) or a conventional wound pad dressing with fiber tape (n=50).[37] The authors found patients who received the Hydrofiber® dressing had significantly fewer local skin-site reactions than those in the other cohort ($p=0.02$). Additionally, although the Hydrofiber® dressing was more costly (€14.70 vs. €8.70), this cost represented only approximately 0.02% of surgical costs, so the authors concluded the modern Hydrofiber® dressing to be better.

Silver-impregnated dressings

Tyagi et al. retrospectively reviewed 275 patients who either received a negative-pressure wound dressing (n=86) or a silver-impregnated wound dressing (n=189).[39] All THAs were performed through a direct anterior approach. The authors did not find any differences in total, superficial, or deep infections between the two cohorts. There was a higher readmission trend for the negative-wound pressure cohort, though this was found to not be significant (9.3 vs. 3.7%; $p=0.12$). The authors also found no differences in postoperative complications in their subgroup analyses of high-risk patients. Therefore, the authors recommended the use of a standard dressing, even in high-risk patients.

Adhesive and polyester mesh dressings

Siddiqui et al. evaluated 211 primary THAs with patients randomized into

three cohorts: 2-octyl cyanoacrylate with an absorptive transparent adhesive waterproof film, 2-octyl cyanoacrylate with a non-absorptive transparent adhesive film, or just an absorptive transparent adhesive waterproof film.[36] The group found a greater proportion of patients whose wounds were closed with 2-octyl cyanoacrylate—in any combination—remained dry on postoperative day one. Additionally, the 2-octyl cyanoacrylate and non-absorptive transparent adhesive film had significantly fewer patients who had increased wound drainage on postoperative days two and three ($p<0.05$).

Herndon et al. retrospectively reviewed data from 323 total hip arthroplasties that were performed from either the direct anterior or mini-anterolateral approaches.[38] For the control cohort, a standard dressing was applied with all sides sealed. In the study cohort, a polyester mesh was placed on the incision length-wise with 2-octyl cyanoacrylate adhesives applied on top. Wound healing delay was noted in seven cases in the study cohort and 15 cases in the standard dressing cohort (3.8 vs. 10.9%, $p=0.01$). There were no differences in reoperations due to wound healing or deep infections between both cohorts.

Negative-pressure wound dressings

An early report by Hansen et al. examined if the use of negative-pressure wound therapy was appropriate for THAs.[40] They studied 109 patients who received negative-pressure wound therapy after hip arthroplasty for the treatment of postoperative incisional drainage between April 1, 2006 and April 1, 2010. They found that while 83 patients (76%) did not require further surgery and 26 patients (24%) had subsequent surgery, there were no wound-related complications associated with negative-pressure wound dressings. Therefore, the authors concluded that the majority of their patients had cessation of wound drainage with negative-pressure wound dressings and that it is a viable dressing option for total hip arthroplasties.

In a different study investigating patients who underwent THAs through a posterior approach, Tyagi et al. compared those who received a negative-pressure wound dressing ($n=92$) to silver-impregnated wound dressing ($n=143$).[41] They found that the infection rate was 2.97% in the silver-impregnated group, compared to 1.20% in the negative-pressure group. Additionally, there were statistically significantly lower readmission ($p=0.028$) and reoperation ($p=0.001$) rates for high-risk patients treated with negative-pressure wound dressings. Therefore, the authors suggest that negative pressure dressings in carefully selected patients may help to reduce reoperations and readmissions in this subgroup.

Summary of wound dressings

Overall, dressing choice is an important decision for successful wound closure following THA. A total of two reports demonstrated increased dryness, decreased wound drainage, and decreased rates of delayed wound healing with use of adhesives and mesh. Based on the current literature, we recommend an occlusive seal, such as a surgical adhesive, with a protective outer bandage. Although some bandages might have a slightly higher upfront cost, it is possible that their cost is still marginal to the overall cost of care.

Capsular closure and short external rotators repair description

Capsular and short external rotator repair can be largely dependent on surgical approach, as some approaches to the hip rely on splitting or moving aside muscle or muscular planes, while others rely on releasing musculo-tendinous junctions that can be repaired. Although these layers are not always closed, it is still important to address them, as some surgeons, particularly those who utilize the posterior approach, rely on these closure techniques. Closing the capsule and repairing the short external rotators can not only potentially provide increased stability, but also an added protective layer for the implant to the outside world. A number of factors contribute to the ability to close the capsule and short external rotators. For example, if the capsule is flapped during the initial approach, allowing for repair, or completely resected, as well as the approach to the hip. In severely degenerated hips, the inflammatory process involved in the joint destruction may result is an incredibly adhered capsule, precluding the ability to properly raise it up and subsequently repair it. Additionally, in some elderly patients, the degeneration of the muscles and tendons might result in continuous fraying each time a suture is passed through, also limiting the ability for repair. A number of studies have commented on capsular and short external rotator repair, with a select few highlighted below.[42–54]

Review of capsular closure and short external rotators repair articles

Tsai et al. reviewed the outcomes of 204 primary, uncomplicated THAs from 181 patients.[48] Of this group, 142 hips with capsulectomy did not undergo capsular repair, while 62 hips underwent posterior capsular repair. For all patients, a standard posterolateral approach was performed. All patients were followed for at least 12 months postoperatively. The group found that 10 out of 142 patients (7%) did not have capsular closure dislocated during follow up, with nine out of 142 (6.4%) having dislocated during the first six months. To the best of these author's knowledge, six out of the seven dislocations occurred independent of any trauma, while one out of seven patients had a fall resulting in dislocation. In the capsular repair cohort, no patients experienced dislocation. Based on these results, the authors concluded that posterior capsular repair should be included as a routine part of hip closure whenever possible.

In another study, White et al. analyzed 1,515 patients who underwent surgery by a single surgeon utilizing the standard posterolateral approach.[49] Of these patients, 1,078 patients (71%) underwent posterior capsulectomy of 40 to 60% of the acetabular circumference. The anterior capsule was left intact. Notably, there was no attempt to reattach the short external rotators. A total of 437 patients (29%) underwent posterior capsule, as well as short external rotator repair. In the non-capsular repair cohort, 52 patients (4.8%) had dislocations within the first six months, while in the capsular/short external rotator repair cohort, only three patients (0.7%, $p=0.001$) experienced dislocations.

Pellici et al. evaluated the outcomes of two separate surgeons who performed an "enhanced posterior repair," which included repair or reconstruction of the posterior capsule, short external rotators, quadratus femoris, and the tendinous insertion of the gluteus maximus.[50] Patients who did not undergo enhanced posterior repair had their short external rotators repaired by the first surgeon, but not the second. Of the 395 patients who underwent enhanced posterior

Table I
Studies highlighting capsular repair

Author	# of Patients	# of Hips	Capsular Repaired	Capsule Not Repaired	Dislocation Rate (Repair vs. Non-Repair)
Tsai et al. [48]	181	204	62	142	0 vs. 7%
White et al.[49]	1,515	X	437	1,078	0.7 vs. 4.8%
Pellici et al.[50]	790	X	395	395	0 vs. 4%
Pellici et al.[50]	284	X	124	160	0.8 vs. 6.3%

repair by the first author, there were no dislocations at one-year follow up. Of the 395 patients who did not undergo enhanced posterior repair by the first author, there were 16 dislocations (4%, $p<0.0001$). For the second surgeon, out of the 124 patients who underwent enhanced posterior repair, one patient (0.8%) dislocated, while in the non-repair cohort, 10 out of 160 (6.3%) patients dislocated ($p=0.014$).

Summary of capsular closure and short external rotators repair

With the above three referenced studies as examples, the authors recommend attempts be made to repair the hip capsule as well as the short external rotators when possible (Table II). This closure can be potentially challenging depending on the level of hip disease and resultant surrounding soft tissue destruction, but closing back the soft tissue space to restore as much native anatomy as possible can be of benefit.

CONCLUSION

Adequate wound closure following total hip arthroplasty is a critical component for the overall success of the operation. A loose closure that does not support hip stability, or one that allows for continuous drainage, and entry of foreign material can all result in catastrophic joint failure. The skin acts as the first and most important barrier to infection, so a watertight closure is essential. There are many modalities to achieve a tight wound closure, and the literature is replete with different materials as well as techniques. A total of two reports demonstrated increased dryness and decreased rates of wound drainage as well as delayed wound healing with use of adhesives and mesh dressings. Additionally, one report found that patients who had skin closure with barbed suture had faster time to a dry postoperative wound and lower rates of delayed discharge. Furthermore, wound closure time can be reduced with barbed sutures as demonstrated by three out of four reports and the meta-analyses, which can potentially, along with decreased number of sutures required as also shown by three out of four reports, result in an overall net savings. Based on the above literature, we recommend performing layered closures from the capsule as well as short external rotators (if taken down during the approach), fascial layer with either a running knotless suture, subcutaneous closure either with the same type of knotless suture as the fascial layer brought more superficially, or with simple interrupted traditional sutures to tack down any empty space, and finally subcuticular and skin sutures with a skin adhesive glue overtop. The skin adhesive can help provide that extra layer, particularly in active patients. However, it is important to let the adhesive fully dry before applying the dressing. An occlusive overlying dressing will also help protect the wound and absorb any potential drainage. As new closure materials and techniques are developed, there is continued need to reassess the current literature so we can continue to provide our patients with the best, most up-to-date practices to ensure optimal patient outcomes. STI

AUTHORS' DISCLOSURES

Dr. Mont is a board or committee member for The Knee Society and The Hip Society, receives research support from National Institutes of Health, and is on the editorial board for the Journal of Arthroplasty, Journal of Knee Surgery, Surgical Technology International, and Orthopaedics. Dr. Mont also receives company support from 3M, Centrexion, Ceras Health, Flexion Therapeutics, Johnson & Johnson, Kolon TissueGene, NXSCI, Pacira, Pfizer-Lily, Skye Biologics, SOLVD Health, Smith & Nephew, Stryker, CERAS Health, MirrorAR, PeerWell, US Medical Innovations, RegenLab, Medicus Works LLC, Up-to Date, Wolters Kluwer Health, Lippincott Williams & Wilkins, Journal of Arthroplasty, Journal of Knee Surgery, Orthopedics, Surgical Technology International, AAHKS, Knee Society, and Hip Society.

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