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Factors Influencing Outcomes in Gluteus Maximus-Tensor Fascia Lata Two-Muscle Tendon Transfer in Patients Receiving Total Hip Arthroplasty: A Retrospective Analysis

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ABSTRACT

Background and Aims: Hip abductor tendon weakness presents a significant challenge in orthopedic practice, often leading to pain, gait disturbances, and compromised function. In many cases, primary repair of the abductor tendons is not feasible due to tendon retraction, poor tissue quality, or chronic degeneration. As a result, tendon transfer procedures have emerged as viable surgical options to restore hip abduction and improve patient outcomes. While these procedures have gained popularity, their effectiveness and complication profiles remain unclear. Our primary aim was to evaluate postoperative outcomes, including Trendelenburg gait, opioid use, readmission, and revision surgery, in patients with total hip arthroplasty undergoing Gluteus Maximus-Tensor Fascia Lata tendon transfer. The secondary aim was to assess the association between patient characteristics (age, sex, Body Mass Index [BMI], smoking status, diabetes, steroid use) and surgical approach with postoperative outcomes, to potentially identify risk factors for complications or poor functional recovery.

Materials and Methods: Demographic data and postoperative pain of 41 total hip arthroplasty patients who underwent Gluteus Maximus-Tensor Fascia Lata tendon transfer at a tertiary medical center between July 2014 and June 2023 were obtained from the Electronic Health Record. Patient factors such as diabetes, steroid use, and smoking status were evaluated for their impact on postoperative recovery.

Results: The cohort's mean age was 68.3 years (standard deviation [SD]=10.0), with most patients being female (73.2%) and White (92.7%). Of the cohort, 46.3% had a BMI ≥30, and 41.5% had a BMI between 25-29.9. Diabetes was present in 26.8%, and 36.6% used steroids. Postoperative opioid refills averaged 3 (SD=3.7). Trendelenburg gait persisted in 56.1%. Surgical site infections occurred in 4.9% of patients, 19.5% were readmitted, and 21.9% required revision surgery, with an average revision time of 24 months (SD=18.9). No significant associations were found between BMI, smoking, or diabetes and opioid refills. Diabetes significantly reduced the risk of Trendelenburg gait (odds ratio (OR): 0.19 [95% confidence interval (CI): 0.41-0.87]), while surgical technique, sex, and smoking did not significantly affect gait. Current smoking significantly increased the risk of readmission (OR: 16.00 [95% CI: 1.22-210.66]).

Conclusion: Gluteus Maximus-Tensor Fascia Lata tendon transfer has emerged as a safe option for irreparable gluteal tendon tears. Further research is needed to refine surgical techniques and better understand the impact of patient characteristics on outcomes. Our findings suggest that patients with certain comorbidities and risk factors can undergo the procedure without significant increases in postoperative complications.

Keywords: Hip abductor tears, gluteus maximus transfer, tendon transfer, tendon reconstruction.

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INTRODUCTION

The Gluteus Medius and Minimus muscle-tendon complex is essential for maintaining pelvic stability and facilitating normal gait mechanics. Abductor insufficiency resulting from degeneration or dysfunction of the Gluteus Medius and Minimus can manifest clinically with a positive Trendelenburg Sign, Trendelenburg gait, and intractable hip pain.[1] Tears in these tendons, often referred to as "rotator cuff tears of the hip," present in three main scenarios: chronic degenerative tears in older adults with lateral hip pain, incidental tears found during total hip arthroplasty (THA) or femoral neck fracture surgery, and avulsion injuries following THA via the anterolateral or transgluteal approach.[1] Magnetic resonance imaging (MRI) is the diagnostic modality of choice for evaluating these injuries and identifying tendon defects and fatty muscle atrophy. If nonsurgical treatment, including Nonsteroidal Anti-Inflammatory Drugs (NSAIDs), physical therapy, and corticosteroid injections, fails to alleviate symptoms, techniques such as open repair with transosseous sutures or endoscopic repair using suture anchors have shown favorable outcomes.[1] In cases where primary tendon repair or reconstruction is not possible due to poor tissue quality, tendon transfer procedures such as Gluteus Maximus tendon flap or Achilles tendon allograft have been explored to restore function.[2-10] The Gluteus Maximus (GMax) tendon transfer technique, first described by Whiteside in 2006 and further refined in 2012, involves rerouting the GMax tendon to the greater trochanter of the femur to restore hip abduction.[2-3]

Since its introduction, GMax tendon transfer has demonstrated improved patient-reported outcomes, typically assessed between one and five years postoperatively, in various case series.[4-9] Several studies have since expanded on the original technique by incorporating additional augmentations to enhance the effectiveness of the transfer. These augmentations include supplementary fixation methods such as Tensor Fascia Lata (TFL) transfer[10] and the use of synthetic mesh.[11] Most studies reporting on GMax tendon transfer have employed an open surgical approach except for one.[12] In addition, a small, retrospective, descriptive study comparing functional outcomes among patients who underwent endoscopic versus open GMax and TFL transfer demonstrated significant improvement in muscle strength, gait, and pain for both techniques.[13] The open surgical technique for tendon transfer remained largely consistent across the studies, with variations mainly involving the use of adjuncts like TFL transfer or synthetic polyethylene to reinforce the muscle transfer.

A systematic review and meta-analysis by Song et al.[14] suggests that while GMax tendon transfer surgeries resulted in statistically insignificant gains in abduction strength (26% mean improvement), their main benefit was pain relief (mean 48.4% decrease in Visual Analog Scale [VAS] score) and improved hip function (mean 30-point increase in modified Harris Hip Score [mHHS]), with overall positive patient-reported outcomes observed over a mean three-year follow-up. Patients undergoing GMax tendon transfer in the literature are typically around 65-70 years old, with a predominance of women. Existing case series tend to include both individuals with native hips and those with prior THA, without distinguishing them on analysis. While 66% of patients experienced an improvement in Trendelenburg gait, about one-third continue to have a residual limp, notable weakness (average abduction strength of 3.4/5) and residual pain (average VAS of 3.1) postoperatively. The overall complication rate is low (5.6%), suggesting the procedure is safe to perform. However, the current literature is limited by small sample sizes, significant variation in surgical techniques, fixation methods, and rehabilitation protocols, all of which can theoretically impact outcomes.

While previous studies have examined postoperative healing and functional recovery, few have explored the impact of patient characteristics and surgical approaches on postoperative outcomes. By analyzing these factors, the study seeks to better understand the variables that impact patient outcomes and improve the overall management of GMax/TFL transfer procedures.

METHODS

This retrospective cohort study was conducted in accordance with the principles outlined in the Declaration of Helsinki. Institutional review board approval was obtained, and the study received an Institutional Review Board (IRB) exemption on September 20, 2024 (#20243055). Current Procedural Terminology (CPT) codes and billing data were queried from a joint Plastic & Reconstructive Surgery and Orthopedic practice at a tertiary care center in Massachusetts. Inclusion criteria consisted of all patients who underwent Gluteus Maximus (GMax) and tensor fasciae latae transfer between July 2014 and June 2023. Exclusion criteria included surgeries performed outside the study institution. We identified 41 eligible patients in our electronic health record (EHR) system, Epic Systems.

Statistical analyses were performed using SPSS Statistics (Version 30; IBM Corp., Armonk, NY, USA). Independent variables obtained from our EHR included age at surgery, sex assigned at birth, race/ethnicity, body mass index (BMI), surgical history, smoking status, presence of diabetes, and use

of systemic corticosteroids within three months of surgery. Dependent variables included the number of postoperative opioid refills, used as a proxy for postoperative pain due to incomplete availability of the Numerical Rating Scale (NRS), and the presence of Trendelenburg gait postoperatively, used as a measure of surgical efficacy. The number of procedure-related readmissions and revisions, as well as the time to revision, were also evaluated.

THA Considerations – Femoral Head Size and Stem Offset

THA encompasses a number of approaches such as posterior, direct anterior, and posterolateral, and utilizes a variety of head sizes and bearing types. The most commonly used femoral head sizes are 32 and 36 mm,[15] having increased in recent years to more closely align with the original size of the native femoral head. This purportedly offers a wider range of motion and reduced risk of dislocation.

Stem offset is the perpendicular distance between the axis of the femur and the center of rotation of the femoral head. Appropriate positioning of the center of rotation maximizes function and improves stability and implant durability. Standard stem offset is classically defined by the patient's sex as 37.5 mm for females and 44 mm for males.[16] Higher stem offset may increase range of motion and abductor strength in THA. The femoral head size and stem offset were recorded for our cohort of patients.

TFL/GMax Transfer Technique

Improving upon the original technique by Whiteside 2012, the TFL and GMax are isolated by elevating the subcutaneous tissue anteriorly to the Smith-Peterson Interval anteriorly and prior to encountering the Inferior Gluteal Artery Perforator (IGAP) posteriorly.[2] No posterior dissection was done inferior to the GMax tendon, while anteriorly, at least 6 cm of the Iliotibial (IT) band was isolated distal to the inferior most aspect of the TFL muscle belly. The TFL was elevated, avoiding nerve and vascular damage to the level of the Smith-P interval. The greater trochanter was visualized, typically having a smooth 'bald eagle sign' from chronic tendinopathy and bursa formation. The bursa was stripped from the greater trochanter and the undersurface of the GMax to increase arc of rotation for the GMax and surface area for adhesion of the undersurface to the greater trochanter. Additionally, a superficial cortical osteotomy was performed to increase the area for muscle adhesion. The upper third of the GMax tendon was divided and fascia and muscle were scored along the direction of the GMax muscle fibers until the muscle was able to rotate over the greater trochanter. Holes were drilled in the greater trochanter and #5 Ethibong was passed with the assistance of a suture passer. The hip was positioned in neutral abduction and the GMax flap tensioned over the greater trochanter, then secured. Next, the TFL flap was directed posteriorly, with the tendon passing posterior to anterior beneath the origin of the Vastus lateralis and secured to itself proximally, the Vastus tendon, the GMax tendon and the GMax flap, ensuring multiple points of fixation under appropriate tension (Fig. 1).

Statistical Analysis

Descriptive statistics were computed for all patient characteristics, including means with 95% confidence intervals (CI) for continuous variables and proportions with 95% CIs for categorical variables.

Multivariate logistic regression analysis was then performed to identify independent predictors of postoperative complications. Adjusted odds ratios (ORs) with corresponding 95% confidence intervals were reported to quantify the strength of associations. A p-value of <0.05 was considered statistically significant. All statistical analyses were conducted using IBM SPSS Statistics (Version 30, IBM Corp., Armonk, NY, USA).

RESULTS

Characteristics of Study Sample

Between 2014 and 2023, 41 patients underwent TFL and Gmax transfer. Mean age was 68.3 years (standard deviation [SD]=10.0). A majority of patients were female (73.2%) and White (92.7%). Of the patients, 46.3% had a BMI ≥30, while 41.5% had a BMI between 25 and 29.9. Femoral head size was 36 mm. Among the patients, 41.5% had never smoked, 43.9% previously smoked, and 14.6% were active smokers at the time of the procedure. Diabetes was present in 26.8% of the patients, and 36.6% used steroids at the time of surgery (Table 1). The majority of patients underwent direct lateral surgical approach (70.7%), followed by direct anterior (14.6%) and anterolateral (7.3%) approaches. Only 7.3% underwent the posterior approach (Table 2).

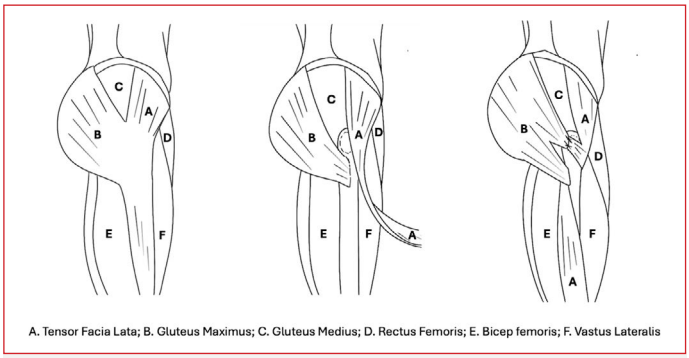

Figure 1. Illustration of the TFL/GMax transfer technique.

Table 1. Patient characteristics

Characteristic	Total (n=41)
Mean age at presentation, months (SD)	68.3 (10.0)
Sex assigned at birth, n (%)	
Female	30 (73.2)
Male	11 (26.8)
Race, n (%)	
White	38 (92.7)
Non-White	2 (4.9)
Unknown	1 (2.4)
BMI, n (%)	
<22	2 (4.9)
22-24.9	3 (7.3)
25-29.9	17 (41.5)
≥30	19 (46.3)
Smoking status, n (%)	
Never smoked	17 (41.5)
Previously smoked	18 (43.9)
Currently smokes	6 (14.6)
Diabetes, n (%)	11 (26.8)
Steroid use, n (%)	
Never used	23 (56.1)
Current use	15 (36.6)
Use at time of surgery	3 (7.3)
Stem offset, n (%)	
Standard	22 (53.7)
High	9 (22.0)
Unknown	10 (24.4)

Surgical Outcomes

Postoperatively, the average number of opioid refills post-surgery was 3 (SD=3.7). Postoperative Trendelenburg gait was observed in 56.1% of patients. Surgical site infections occurred in 4.9% of patients, 19.5% were readmitted, and 21.9% required revision surgery. The average time to revision was 24 months (SD=18.9) (Table 3).

No significant associations were identified between risk factors including BMI, smoking, and diabetes and postoperative pain requiring more than one opioid refill. Diabetes significantly reduced the risk of postoperative Trendelenburg gait (OR: 0.19 [95% CI: 0.41-0.87]). While surgical technique, smoking status, steroid use, and prior surgeries did not significantly impact the risk of postoperative Trendelenburg gait.

Table 2. Operative characteristics

Surgical approach	n (%)
Anterolateral	3 (7.3)
Direct anterior	6 (14.6)
Direct lateral	29 (70.7)
Posterior	3 (7.3)

Table 3. Surgical outcomes

Outcome	
Mean opioid refills, n (SD)	3 (3.7)
Surgical site infection, n (%)	2 (4.9)
Trendelenburg, n (%)	23 (56.1)
Readmission, n (%)	8 (19.5)
Revision, n (%)	9 (21.9)
Mean time to revision, months (SD)	24 (18.9)

Current smokers demonstrated significantly increased risk, with an odds ratio of 16.00 (95% CI: 1.22-210.66) for readmission. Sex, surgical technique, BMI, presence of diabetes, steroid use, and surgical factors did not significantly impact risk. Similarly, no specific variables were shown to impact the odds of postoperative revision.

DISCUSSION

Overall, while several factors such as diabetes and smoking history show promising associations with postoperative outcomes, the wide confidence intervals in many of the odd ratios suggest areas where more precise data are needed. While current smoking showed a high odds ratio for readmission (OR=16.00), the wide confidence interval (1.22-210.66) reflects variability that warrants further investigation. Diabetes was associated with a moderate reduction in the odds of postoperative Trendelenburg gait (OR=0.19, [95% CI: 0.41-0.87]). Even though most patient factors were not shown to impact analyzed postoperative outcomes, these findings offer valuable insights, highlighting potential trends that, with further investigation, could lead to a clearer understanding of factors influencing outcomes. Risk factors like diabetes and smoking may influence postoperative outcomes but do not universally predict failure (Table 4). The absence of significant associations for some factors (e.g., BMI, steroid use) suggests that many patients with comorbidities can safely undergo this procedure without significantly heightened risk, and the presence of these patient characteristics may influence outcomes but does not universally predict failure.

Table 4. Association of patient risk factors with postoperative outcomes

Risk Factor	OR for postoperative pain requiring >1 opioid refill (95% CI)	OR for postoperative Trendelenburg gait (95% CI)	OR for postoperative readmission (95% CI)	OR for postoperative revision (95% CI)
Sex				
Male	1 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Female	0.50 (0.89-2.81)	0.65 (0.16-2.79)	0.53 (0.10-2.74)	0.35 (0.07-1.66)
BMI				
<30	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
≥30	2.00 (0.49-8.20)	0.51 (0.15-1.80)	0.64 (0.13-3.11)	0.91 (0.21-4.01)
Smoking status				
Never smoked	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Previously smoked	0.31 (0.63-1.48)	0.86 (0.22-3.39)	4.57 (0.46-45.86)	8.00 (0.85-75.56)
Currently smokes	0.43 (0.52-3.52)	0.11 (0.01-1.16)	**16.00 (1.22-210.66)**	8.00 (0.57-111.96)
Diabetes				
No	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Yes	2.37 (0.43-13.13)	**0.19 (0.41-0.87)**	1.88 (0.36-9.65)	0.73 (0.13-4.20)
Steroid use				
Never used	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Previously used	0.75 (0.18-3.12)	1.15 (0.31-4.33)	0.55 (0.09-3.31)	0.44 (0.08-2.52)
Currently uses	0.75 (0.57-9.87)	0.39 (0.30-4.87)	1.80 (0.13-24.16)	1.42 (012-18.56)
Stem offset				
Standard	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
High	3.27 (0.33-31.91)	2.00 (0.40-10.09)	2.25 (0.38-13.07)	2.25 (0.39-13.07)
Prior ipsilateral surgeries				
0-1	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
≥2	0.40 (0.99-1.58)	1.44 (0.41-5.04)	0.72 (0.147-3.52)	1.03 (0.23-4.56)

OR: Odds ratio; CI: Confidence interval. Bolded values indicate statistically significant associations ($p<0.05$).

Patients in our study underwent surgical intervention for Gluteus Medius and Minimus tendinopathy to address persistent lateral hip pain and/or Trendelenburg gait that had not responded to conservative management. While abductor insufficiency is a common cause of a positive Trendelenburg sign, it is not the sole etiology; other factors such as neurologic deficits, superior gluteal nerve injury, and structural abnormalities may also contribute.[2] Gluteus Medius and Minimus tendinopathy, often referred to as the "rotator cuff of the hip," is increasingly recognized as a major contributor to persistent lateral hip pain. Surgical intervention in this area aims to restore function, alleviate pain, and improve quality of life. Even though the current literature on this procedure is limited, available studies suggest significantly improved patient-reported outcomes, consistently meeting or exceeding the minimal clinically important difference and patient-acceptable symptom state thresholds.[14] However, predicting surgical success and selecting the best candidates for surgery remain difficult. Key risk factors for poor outcomes include significant fatty infiltration or muscle atrophy, as seen on MRI and classified using the Goutallier-Fuchs scale, as well as abnormal femoral neck shaft angle, lateral center edge angle, and thickening of the Gluteus Medius.[17]

As Allahabadi et al.[18] demonstrate in their study, full-thickness tears with greater than or equal to 2 cm of retraction (MRI grade 3) carry the highest risk of failure, with these more chronic tears being less likely to heal successfully. Lifestyle and health

factors such as smoking, preoperative back pain, psychiatric disorders, and the presence of Trendelenburg gait have all been identified as predictors of treatment failure. GMax/TFL tendon transfer offers a salvage option for failed repairs or irreparable tears and overall led to improvements in patient-reported outcomes such as pain and functional mobility, though with less consistent gains in abductor strength or Trendelenburg gait.[14] However, studies on GMax/TFL tendon transfer have not yet comprehensively linked patient characteristics with postoperative outcomes. Our study aims to address these gaps by examining the impact of demographic, clinical, and surgical variables on postoperative recovery.

Limitations

Our study highlights the potential of GMax/TFL tendon transfer for Gluteus Medius and Minimus tendinopathy while identifying areas for improvement in research methods to enhance future outcomes. Although we utilized the number of opioid refills as a proxy for postoperative pain, we were ultimately unable to definitively compare pre- and postoperative pain levels or Trendelenburg gait improvements due to insufficient reporting. This provides an opportunity to refine our data collection protocols. Standardizing how pain and functional status are recorded in EHR and potentially incorporating more objective measurements such as VAS or mHHS scores can ensure consistent and reliable assessments of these variables in future studies. In addition, having longer follow-up periods will allow for a more comprehensive evaluation of long-term recovery and outcomes, leading to a more robust framework for future clinical decision-making.

CONCLUSION

Current literature supports both open and endoscopic GMax/TFL tendon transfer techniques for irreparable gluteal tendon tears, although evidence for endoscopic methods remains more limited. As larger, long-term studies emerge, surgical techniques and recommendations are likely to be refined to optimize outcomes. Future research should focus on better understanding patient characteristics and their impact on outcomes, as well as incorporating more objective measures, such as gait analysis and dynamometry, to more accurately assess improvements in abduction strength and gait recovery.

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Informed Consent: Written informed consent was not required due to the retrospective nature of the study.

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