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Case Report

Parallel tunnel ligamentopexy-a novel technique for medial collateral ligament deficiency in primary total knee arthroplasty: a case study

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ABSTRACT

Managing medial collateral ligament (MCL) deficiency in primary total knee arthroplasty (TKA) remains a challenge, often necessitating constrained implants or revision prostheses. We present an innovative technique, Parallel Tunnel Ligamentopexy, which stabilizes the MCL without requiring revision implants, thus preserving native structures and reducing bone loss. A 68-year-old male with severe varus deformity and grade 4 osteoarthritis of the left knee presented with progressive difficulty in ambulation and performing daily activities. Radiographic evaluation confirmed knee subluxation. The patient underwent left-sided TKA. Intraoperatively, a femoral attachment deficiency of the MCL was observed. Parallel tunnel ligamentopexy was performed by whip-stitching the residual MCL, creating two parallel 2-mm tunnels in the lateral distal femur, and securing the MCL using these tunnels. This approach was preferred over semitendinosus augmentation, given its reduced risk of supracondylar femoral fractures and improved suitability for osteoporotic bones. The patient was mobilized on postoperative day 1. The varus deformity was corrected, and knee stability was maintained. At six months follow-up, clinical and radiological evaluations demonstrated no signs of MCL laxity. The patient resumed daily activities independently, highlighting the efficacy of Parallel Tunnel Ligamentopexy in preserving knee stability without requiring a constrained implant. Parallel Tunnel Ligamentopexy is a cost-effective, biologically favorable solution for MCL deficiency in primary TKA. This technique avoids constrained implants, minimizes bone loss, and optimizes functional outcomes, particularly in osteoporotic patients.

Keywords: Total knee arthroplasty, Parallel tunnel ligamentopexy, Primary knee replacement, Varus deformity, Osteoarthritis grade 4, Femoral tunnel technique

INTRODUCTION

Total knee arthroplasty (TKA) is a highly effective surgical intervention for end-stage knee osteoarthritis, with steadily increasing global demand due to an aging population and higher expectations for mobility in older adults. A crucial component of successful TKA is the maintenance of soft tissue balance, particularly the integrity of the medial collateral ligament (MCL), which plays a central role in mediolateral knee stability.[1,2] MCL deficiency-whether due to chronic attenuation, intraoperative injury, or preexisting pathology-poses a significant challenge in TKA.

Traditional approaches recommend the use of constrained or semi-constrained prostheses in such scenarios to ensure joint stability. However, constrained implants are associated with increased stress on fixation interfaces, greater bone loss, higher cost, and potential for accelerated wear, leading to earlier revision.[3,4] Alternative methods, such as semitendinosus graft augmentation, though effective, involve extensive soft tissue handling, larger

bone tunnel formation, and are associated with an increased risk of supracondylar femoral fractures-especially in osteoporotic patients.[5,6] There is thus a need for a minimally invasive, structurally sound, and cost-effective approach for MCL stabilization during primary TKA.

Authors describe a novel technique called parallel tunnel ligamentopexy, designed to restore MCL function using a biological method that avoids constrained prostheses and extensive graft harvesting. This method is particularly suitable for patients with osteoporosis and significantly reduces the risk of iatrogenic fracture while achieving functional outcomes comparable to traditional methods.

CASE REPORT

A 68-year-old male presented to our outpatient clinic with a history of bilateral knee pain for over five years, worsened in the left knee, along with difficulty in ambulation, climbing stairs, and performing daily activities. His past medical history was unremarkable except for controlled hypertension. Physical examination revealed pronounced varus deformity of the left knee, joint line tenderness, and medial instability. The range of motion was limited to 10°–90°, with audible crepitus. Weight-bearing anteroposterior and lateral radiographs demonstrated Kellgren–Lawrence grade 4 osteoarthritis with joint space obliteration and medial subluxation. The femorotibial angle showed approximately 18 degrees of varus deformity. After evaluation and consent, the patient was scheduled for left total knee arthroplasty.

Intraoperatively, the MCL femoral attachment was found to be deficient. Instead of converting to a constrained TKA design or performing semitendinosus augmentation, we implemented our novel technique. The residual MCL tissue was whip-stitched using a non-absorbable suture. Two 2-mm parallel tunnels were drilled transversely across the lateral distal femur using a guidewire and cannulated drill system. The whip-stitch sutures were passed through these tunnels, redirected laterally, and securely tied to restore MCL tension and alignment.

This technique provided robust medial stability with minimal additional surgical trauma. The standard primary TKA prosthesis was implanted without additional constraint. The patient was mobilized on postoperative day 1 with partial weight-bearing using a walker. Physical therapy included quadriceps strengthening, passive and active range of motion, and gait training. He was discharged on postoperative day 4 with an independent home exercise protocol. At six months follow-up, the patient demonstrated full weight-bearing capacity, pain-free ambulation, and knee flexion up to 115°. Clinical varus-valgus stress testing revealed no signs of instability. Radiographs showed proper implant positioning without evidence of loosening or subluxation.

Figure 1: (a) Pre-op patient stance (b) pre-Op X-ray B/L knee lateral view and (c) pre-op X-ray B/L knee AP view.

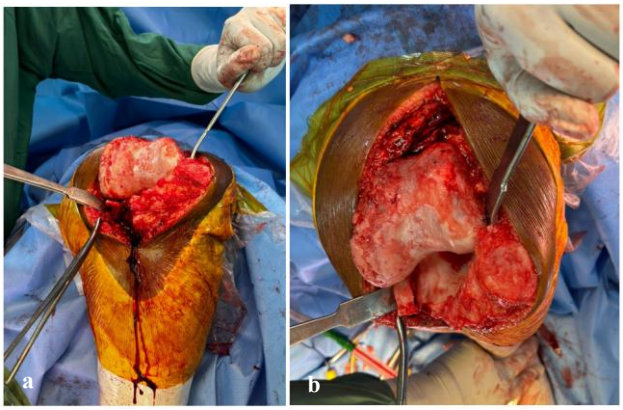

Figure 2: (a) Intra op–femoral head mobilization and (b) intra op–ligament identification for tunneling.

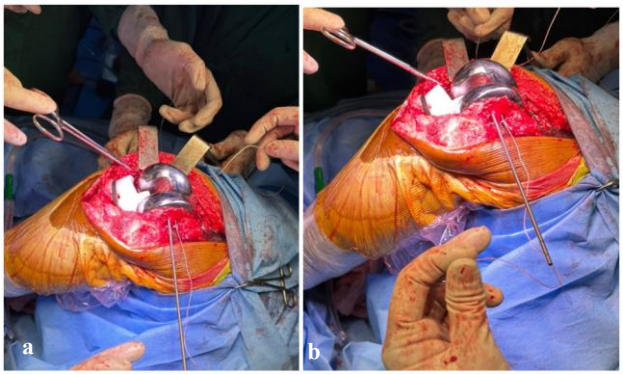

Figure 3 (a and b): Parallel tunneling and ligamentopexy.

Figure 4 (a and b): Post op X-rays with implants in-situ.

DISCUSSION

The MCL is the primary stabilizer against valgus stress in the knee, and its integrity is essential for optimal postoperative outcomes in TKA.[7,8] Management strategies for MCL deficiency during TKA typically fall into three categories: use of constrained prostheses, soft tissue reconstruction or augmentation, and combined techniques.

Constrained prostheses offer immediate stability but lead to increased mechanical stresses at the bone-implant interface, resulting in higher rates of aseptic loosening and revision. These implants are also more expensive and necessitate greater bone resection, which is not ideal in elderly or osteoporotic individuals.[9,10] Soft tissue augmentation using autografts, such as semitendinosus or gracilis, is a biologically favorable option but involves additional surgical morbidity and carries risks such as graft failure or femoral fracture due to large tunnel formation.[11]

Parallel tunnel ligamentopexy avoids these complications by utilizing a smaller tunnel size (2 mm), thus minimizing bone removal and maintaining the mechanical integrity of the distal femur. This approach is particularly beneficial in patients with low bone mineral density, where preserving cortical bone is critical.[12] Biomechanically, this method effectively redirects tensile forces from the medial side to a stable lateral anchor point via the femoral tunnel system. Similar concepts have been employed in ligament reconstruction in the shoulder and ankle, where parallel tunnel configurations have yielded strong, durable fixation.[13,14]

The simplicity of this procedure, minimal invasiveness, reduced cost, and absence of hardware makes it a highly attractive solution. Additionally, early mobilization reduces the risk of postoperative stiffness and thromboembolic events—another significant benefit for geriatric patients.[15] To Authors knowledge, this is the first reported use of the parallel tunnel ligamentopexy technique in the context of primary TKA. The favorable outcome in our patient supports further exploration of this method in larger clinical studies and suggests that, in select cases, primary implants can be successfully retained even in the presence of MCL deficiency.

CONCLUSION

Parallel tunnel ligamentopexy is a novel and effective technique for managing medial collateral ligament deficiency in primary total knee arthroplasty. By utilizing whip-stitch reinforcement and femoral tunnel redirection, it restores medial stability without the need for constrained implants or tendon grafts. This approach is particularly suited for elderly patients with osteoporotic bone and may significantly reduce the risk of revision surgery, costs, and postoperative complications. This case underscores the importance of innovation in surgical technique to balance stability, biology, and economics. Larger prospective studies are warranted to validate the reproducibility, safety, and long-term outcomes of this promising method.

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