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Research Article

Resolution of Fixed Flexion Contracture Following Kinematically Aligned Manual Total Knee Arthroplasty Without Raising the Joint Line

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Background

Persistence of fixed flexion contracture (FFC) following total knee arthroplasty (TKA) is a common occurrence, resulting in poor postoperative outcomes. Soft tissue releases and distal femoral resection have been previously studied in attempts to address this issue. There is a scarcity of literature on the resolution of FFC following primary kinematically aligned (KA) manual TKA without raising the joint line. In this study, we evaluated post-operative range of motion (ROM) in patients with a preoperative FFC following primary KA TKA without raising the joint line.

Methods

Eighty-five patients with preoperative FFC who underwent a primary KA TKA without distal femoral resection by a single arthroplasty-trained surgeon were identified. Demographics and pre-operative range of motion were obtained. Primary outcomes included post-operative range of motion at 6-weeks and one-year. Secondary outcomes included infection, revision rates, manipulation under anesthesia, and wound complications.

Results

A total of 85 patients were included, with an average pre-operative extension of 5.5° (std dev, 2.2°). Of the 85 patients, 5 had a flexion deformity within 5° of full extension, with the other 80 patients having extension ⩾5° to 20°. Post-operatively, 21.2% and 5.9% of patients had a flexion contracture at 6-weeks and one-year respectively. Average post-operative extension at 6-weeks was 1.5° (std dev, 4.1°) and 0.5° (std dev, 2.3°) at one-year.

Conclusion

In this study, we found improvement in flexion deformity at 6-weeks and 1-year following primary KA TKA without raising the joint line. There were two cases of manipulation under anesthesia for post-operative joint stiffness.

a Conflicts of Interest Statement for Whisper Grayson

b Conflicts of Interest Statement for Carlo Eikani

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INTRODUCTION

Fixed flexion contracture (FFC) is a common sequela of degenerative joint disease, present in up to 61% of patients prior to total knee arthroplasty (TKA) (Tew and Forster 1987). This condition prevents full extension of the knee joint, resulting in pain and reduced patient mobility (Campbell and McGonagle 2021). The presence of a preoperative flexion contracture has been associated with an increased risk of postoperative contracture, contributing to poor patient outcomes (Ritter et al. 2007; Su 2012; Ritter et al. 2003). Thus, correction of FFC during TKA is an important goal, with recent studies focused on ways of regaining full extension in these patients (Scuderi and Kochhar 2007; Bellemans et al. 2006; Kyriakidis et al. 2022; Liu, Reidy, and Beller 2016).

Historically, techniques including distal femoral resection and soft tissue releases have been employed in attempts to resolve FFC (Scuderi and Kochhar 2007; Bellemans et al. 2006; Kyriakidis et al. 2022; Liu, Reidy, and Beller 2016). More recently, it has been suggested that soft tissue releases are able to correct most FFC without the need for distal femoral resection (Bellemans et al. 2006). Kinematically aligned (KA) TKA is a technique that aims to reproduce pre-arthritic anatomy and hence does not involve releasing collateral or posterior cruciate ligaments (Sappey-Marinier and Bini 2023). It is felt that by restoring native anatomy and removing osteophytes, this should restore native motion to within the limits of the prosthesis (Sappey-Marinier and Bini 2023). Therefore, theoretically with this technique additional distal femur resection should not be necessary to restore full extension with the potential exception of extreme cases (Sappey-Marinier and Bini 2023). However, there are few studies that demonstrate this clinically, and most published studies have utilized robotic assistance.

This study primarily aims to evaluate the impact of primary manual KA TKA on FFC in patients ⩾18-years old without raising the joint line by assessing pre- and post-operative range of motion. Secondary aims include assessing post-operative complications.

METHODS

This was an IRB approved retrospective cohort study. Chart review was used to identify all consecutive patients who had undergone a primary kinematically-aligned total knee arthroplasty between October 2021 and August 2023. A total of 203-patients who underwent a primary kinematically-aligned total knee arthroplasty were identified during this enrollment period. Of these patients, 74 were excluded for less than one-year follow-up and an additional 34 patients were excluded for the absence of a pre-operative flexion contracture. The remaining 95-patients were included in this study.

All patients were operated on by a single arthroplasty-trained surgeon at our institution, the senior author (NMB), who began performing kinematically aligned TKA in October 2021. The surgical technique was unrestricted kinematic alignment where the goal is reproducing pre-arthritic anatomy by calipering each cut and replacing the thickness of bone and cartilage with the metal components (Howell, Roth, and Hull 2014). Careful measurement of cartilage, measurement of the resected pieces with the goal of accurately restoring native anatomy including posterior femoral condylar offset, and diligent resection of osteophytes were used to address the flexion contractures. All patients received a depuy attune cruciate retaining (CR) knee. Twenty-four patients had a rotating platform (RP) poly and 71 had a medial stabilized (MS) poly. All TKAs were performed with a manual, unrestricted femur first technique aiming to restore pre-arthritic anatomy. Patients were further chart-reviewed to ensure no additional distal femoral resection was performed during the operation. Inclusion criteria included all patients with a pre-operative flexion contracture, which was defined as lack of full extension. Exclusion criteria included patients under 18-years old and/or with less than one-year follow-up.

Variables of interest included baseline demographics (gender, race/ethnicity, age at time of TKA, BMI, tobacco use, hypertension, diabetes mellitus, follow-up time, and Charlson Comorbidity Index) and pre-operative range of motion. The primary outcomes documented were post-operative range of motion at 6-weeks and one-year post-TKA, which was measured in office by the surgeon. Secondary outcomes evaluated included rates of superficial surgical site infection within 30-days post-operative (defined as superficial tissue infection treated with oral antibiotics), deep surgical site infection within 90-days post-operative (defined as return to the operating room for irrigation and debridement), aseptic loosening, manipulation under anesthesia, revision surgery, periprosthetic fractures, and wound dehiscence.

RESULTS

A majority (67.4%) of the patients were female, with an average age of 67.0 years (std dev, 9.3). The minimum follow-up time was one-year, with an average follow-up time of 16.4-months (std dev, 5.4). Common comorbidities include obesity with an average BMI of 34.1 (std dev, 6.5), hypertension (70.5%), and diabetes mellitus (31.6%). The average Charlson Comorbidity Index (CCI) was 3.2 (std dev, 1.8) (**Table 1**).

All patients had a documented pre-operative fixed flexion contracture, with an average pre-operative extension of 5.5° (std dev, 2.1°) and pre-operative flexion of 116.7° (std dev, 7.8°). Of the 95 patients, 5 had a flexion deformity

within 5° of full extension, with the other 90 patients having extension ⩾5° to 20°. Post-operatively, 18.9% and 5.3% of patients had a flexion contracture at 6-weeks and one-year respectively. Average post-operative range of motion at 6-weeks was 1.3° of extension (std dev, 3.9°) and 113.0° of flexion (std dev, 12.7°). The same values at one-year post-operative were 0.5° (std dev, 2.2°) and 123.4° (std dev, 8.0°) respectively **(Table 2)**. The pre- and post-operative range of motion for patients with a persistent flexion deformity are summarized at 6-weeks **(Table 3)** and one-year **(Table 4)**. Out of the 95 patients, 8 patients had a pre-operative flexion contracture between 10° and 20°. Two of these patients had a post-operative flexion contracture at 6-weeks and one had a persistent flexion contracture at one-year.

Complications were infrequent, with one patient experiencing wound dehiscence treated non-operatively. Two patients required manipulation under anesthesia. This resulted in a pre-MUA motion of 0-85° and 5-80° and post MUA motion of 0-115° and 0-120° respectively. One patient had a superficial surgical site infection managed non-operatively with oral antibiotics. Lastly, one patient required re-operation for liner exchange due to laxity resistant to non-operative management **(Table 5)**.

DISCUSSION

Persistence of fixed flexion contracture following TKA is a common occurrence, resulting in poor patient function and outcomes (Su 2012). While distal femoral resection during TKA has been well-described as a successful management technique in the literature, it can result in midflexion instability and patella baja (Hardy et al. 2023; Luyckx et al. 2018). Given these potential outcomes, more recent studies have proposed that contracture resolution can be achieved without raising the joint line (Bellemans et al. 2006; Sappey-Marinier and Bini 2023; Hardy et al. 2023). This study evaluated the resolution of preoperative FFC following primary KA TKA without distal femoral resection and found improvement in flexion deformity at 6-weeks and one-year.

This study aligns with current literature by seeking to find novel techniques to manage flexion deformities during TKA. An et al, published a systematic review containing twenty-five studies demonstrating that the only patient predictor for post-operative FFC was preoperative FFC (An, Scholes, and Fritsch 2018). These studies further highlighted distal femoral resection, soft tissue balancing, and posterior condylar offset to be important factors in correcting FFC intraoperatively (An, Scholes, and Fritsch 2018). A study by Leie et al corroborated these findings with their study demonstrating posterior femoral condyle offset being an important variable impacting the correction of flexion contracture during TKA (Leie et al. 2022). A kinematically aligned total knee arthroplasty aims to restore pre-arthritic anatomy and therefore has the goal of restoring native posterior femoral condylar offset.

The degree of preoperative flexion contracture also significantly impacts the steps needed to improve post-operative outcome. Bellemans et al., conducted a retrospective study and found that 98.6% of flexion contractures less than 30 degrees can be corrected with soft tissue releases and minimal femoral resection up to 2mm (Bellemans et al. 2006). Their results demonstrated that while contractures greater than 30 degrees could often be treated with these steps alone, additional femoral resection and hamstring tenotomy were often necessitated (Bellemans et al. 2006). In our study, 5.3% of patients had a flexion contracture less than 5 degrees preoperatively, with the remaining 94.7% having a deformity between 5 to 20 degrees. There were no patients meeting study criteria with a preoperative deformity exceeding 20 degrees, thus presenting a limitation to this study.

Recent studies have geared towards correcting preoperative flexion deformities without additional bony resection. Moya-Angeler et al., examined robot-assisted KA TKA in patients with and without preoperative FFC in attempts to address whether additional femur and/or tibial resection are needed to resolve the flexion deformity (Moya-Angeler et al. 2023). Their findings showed that full extension was achieved in patients without additional femoral resection and only minimal tibial resection (Moya-Angeler et al. 2023). A similar study performed by Sappey-Marinier et al., evaluated patients with FFC who underwent robotic KA TKA, with all patients reaching within five degrees of full extension without raising the joint line (Sappey-Marinier and Bini 2023). Our findings support these studies with most patients achieving full extension by one-year post-operative. Of the five patients with a persistent flexion contracture at one-year, one was primarily wheelchair bound, one had a pre-existing ipsilateral foot drop and sciatic nerve injury, one had sustained a severe brain injury as a child leading to hemiplegia and contractures, and the other two had chronic post-operative pain. These circumstances likely contributed to their post-operative flexion deformity.

There have been a number of studies demonstrating that the majority of flexion contractures will resolve without additional distal femoral resection with a mechanically aligned technique. A paper by Whiteside and Mihalko demonstrated that out of 552 knees, only 2% required over-resection of the distal femur to correct flexion deformity, with most resolving with soft-tissue releases (Whiteside and Mihalko 2002). Recent studies have also suggested that KA TKA is able to achieve the same amount of flexion deformity correction as MA TKA, with less bony and soft tissue resection (An et al. 2019). It has been the author's experience that these resolved quicker and easier with a kinematic technique. Nonetheless, when utilizing a mechanically aligned technique with careful attention to joint line restoration, posterior condylar offset, and resection of osteophytes, the data suggests that most flexion contractures will resolve (Whiteside and Mihalko 2002). Additionally, it should be noted that while we utilized a manual calipered kinematic technique, this restoration of native anatomy can be achieved in a variety of methods using manual cutting blocks, custom cutting blocks, navigation, or robotics (Rivière et al. 2020).

The retrospective design of this study inherently presents limitations, including the potential for recall bias. Furthermore, the single-surgeon nature of this study limits the generalizability of these results. The lack of patients with a preoperative flexion deformity greater than twenty-degrees also limits the applicability of this study to patients with larger deformities. Additional limitations include the lack of full-length leg films, which limits our ability to discuss coronal plane data, and the high loss to follow-up rate. Finally, individual patient factors including ambulatory status, participation in physical therapy, and activity level could play a role in the persistence of flexion deformities following surgery. These specific variables could not consistently be collected across the entire cohort, thus presenting a potential confounding factor. Further large-scale studies are warranted to further evaluate the impact of primary KA TKA on FFC resolution without raising the joint line.

CONCLUSION

This study found improvement in preoperative flexion deformity following primary kinematically aligned total knee arthroplasty without the use of distal femoral resection in patients with a pre-operative flexion contracture ⩽20°. Of note, two patients required manipulation under anesthesia for joint stiffness post-operatively.

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APPENDIX

Table 1. Primary Kinematic TKA - Demographics (n=95)

	TKA Cohort n = 95
Average Age at TKA (years)	67.0 (9.4)
Average Follow-up (months)	16.4 (5.4)
Gender Female Male	67.4% (64) 32.6% (31)
Race/Ethnicity Caucasian African American Hispanic Asian Other	60.0% (57) 15.8% (15) 12.6% (12) 1.1% (1) 10.5% (10)
Average Charlson Comorbidity Index	3.2 (1.8)
BMI	34.1 (6.5)
Tobacco Use Current Former Never	4.2% (4) 34.7% (33) 61.1% (58)
Hypertension (% Yes)	70.5% (67)
Diabetes Mellitus (% Yes)	31.6% (30)

Means and Standard Deviations provided for continuous variables; Percentages and Sample size provided for categorical variables.

Table 2. Pre- and Post-operative Range of Motion (n=95)

	TKA Cohort n = 85
Average Pre-operative Extension	5.4 (2.1)
Average Pre-operative Flexion	116.7 (7.8)
Post-operative FFC Present (% Yes) 6-weeks post-op 1-year post-op	18.9% (18) 5.3% (5)
Average Post-operative Extension 6-weeks post-op 1-year post-op	1.3 (3.9) 0.5 (2.2)
Average Post-operative Flexion 6-weeks post-op 1-year post-op	113.0 (12.7) 123.4 (8.0)

Means and Standard Deviations provided for continuous variables; Percentages and Sample size provided for categorical variables.

Table 3. Pre- and Post-Operative Range of Motion for Patients with Flexion Deformity at 6-weeks

Patient	Pre-Operative Range of Motion	Post-Operative Range of Motion at 6-weeks
1	5-95°	5-100°
2	5-120°	4-115°
3	20-85°	10-100°
4	5-115°	30-95°
5	5-120°	5-90°
6	5-120°	5-120°
7	5-120°	3-110°
8	5-120°	5-90°
9	5-110°	5-90°
10	5-120°	15-110°
11	10-115°	3-125°
12	5-125°	3-125°
13	5-125°	5-90°
14	5-120°	5-110°
15	7-120°	3-105°
16	5-120°	10-90°
17	5-120°	5-80°
18	5-110°	5-85°

Table 4. Pre- and Post-Operative Range of Motion for Patients with Flexion Deformity at 1-year

Patient	Pre-Operative Range of Motion	Post-Operative Range of Motion at 1-year
1	20-85°	15-100°
2	5-115°	10-95°
3	5-115°	5-125°
4	5-120°	5-110°
5	5-120°	10-130°

Table 5. Post-operative Outcomes Following Primary Kinematic TKA (n=95)

	TKA Cohort n = 95
Superficial Surgical Site Infection	1.1% (1)
Deep Surgical Site Infection	0% (0)
Aseptic Loosening	0% (0)
Manipulation Under Anesthesia	2.1% (2)
Revision Surgery	1.1% (1)
Periprosthetic Fracture	0% (0)
Wound Dehiscence	1.1% (1)

Percentages and Sample size provided for categorical variables.