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A Medial Pivot Negates Tuberosity Offset at Ninety Degrees of Knee Flexion

Dr Peter McEwen

MBBS FRACS FAOrthA DipModLang

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The Knee

The influence of intraoperative soft tissue balance on patellar pressure in posterior-stabilized total knee arthroplasty

Tomoyuki Matsumoto [a,*], Nao Shibanuma [b], Koji Takayama [a], Hiroshi Sasaki [b], Kazunari Ishida [a], Takehiko Matsushita [a], Ryosuke Kuroda [a], Masahiro Kurosaka [a]

[a] Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, Kobe, Japan
[b] Department of Orthopaedic Surgery, Kobe Kaisei Hospital, Kobe, Japan

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ABSTRACT

Background: Appropriate soft tissue balance is essential for the success of total knee arthroplasty (TKA), and assessment with an offset-type tensor provides useful information about the femorotibial (FT) joint. The purpose of the study was to investigate the relationship between intraoperative soft tissue balance and patellar pressure at both medial and lateral sides.

Methods: Thirty varus-type osteoarthritis patients who received mobile-bearing posterior-stabilized TKAs were enrolled in the study. Using the tensor, soft tissue balance, including joint component gap and varus ligament balance, was recorded at 0°, 10°, 30°, 60°, 90°, 120°, and 135° with patellofemoral (PF) joint reduction and femoral component placement. Following final prostheses implanted with appropriate insert, the medial and lateral patellar pressures were measured at each flexion angle. A simple regression analysis was performed between each patellar pressure, parameter of soft tissue balance, and postoperative flexion angle.

Results: Both lateral and medial patellar pressures increased with flexion. The lateral patellar pressure was significantly higher than the medial patellar pressure at 60°, 90°, and 135° of flexion ($p < 0.01$). The lateral patellar pressure inversely correlated with the varus ligament balance at 60° and 90° of flexion ($p < 0.05$). The lateral patellar pressure at 120° and 135° of flexion inversely correlated with the preoperative flexion angle ($p < 0.01$).

Conclusion: Soft tissue balance influenced patellar pressure. In particular, a reduced lateral patellar pressure was found at the lateral laxity at flexion, leading to high postoperative flexion angle.

Level of evidence: II.

1. Introduction

1.1. Background

Total knee arthroplasty (TKA) has become a standard operative procedure with good long-term outcomes, and is largely dependent on advanced surgical techniques and prostheses, and the development of surgical instrument and jigs. Appropriate soft tissue balance is also understood to be essential for the success of TKA [1,2]. However, obtaining accurate intraoperative soft tissue balance remains difficult, especially for young surgeons, since experienced surgeons traditionally address soft tissue balance through "subjective feel." Therefore, an offset-type tensor has been developed for TKA, which enables the assessment of soft tissue balance throughout range of motion (ROM) in the knee after TKA, with a reduced patellofemoral (PF) joint and femoral component in place [3]. Assessment with the tensor provides useful information about the femorotibial (FT) joint. A significant reduction in the value of the component gap and varus ligament balance at deep flexion by PF joint reduction indicates the importance of the physiological condition in assessing intraoperative soft tissue balance [4]. A decreased joint gap, especially at extension, after femoral component placement, indicates the importance of intraoperative soft tissue balance measurement with femoral component placement [5], whereas relatively lower flexion gap and varus ligament balance occurs in posterior-stabilized (PS) compared with cruciate-retaining (CR) TKA [6,7]. However, the influence of intraoperative soft tissue balance on the PF joint has not been fully investigated.

PF complications are one of the most problematic issues after TKA. Whereas recent improvements in surgical technique and prosthetic design have decreased these complications [8,9], the percentage of patients who require revision TKA for PF complications ranges from 0.6 to 1.2% [10–12]. Anterior knee pain after TKA has been reported in as many as 49% of patients, [13,14] and was reported to be partially related to high PF pressure [15,16]. Therefore, the relationship between the PF joint and several factors has received great attention. Previous in vitro studies indicated that patellar resurfacing decreased the patellar

* Corresponding author at: Department of Orthopaedic Surgery, Kobe University Graduate School of Medicine, 7-5-1, Kusunoki-cho, Chuo-ku, Kobe 650-0017, Japan. Tel.: +81 78 382 5985; fax: +81 78 371 0344.

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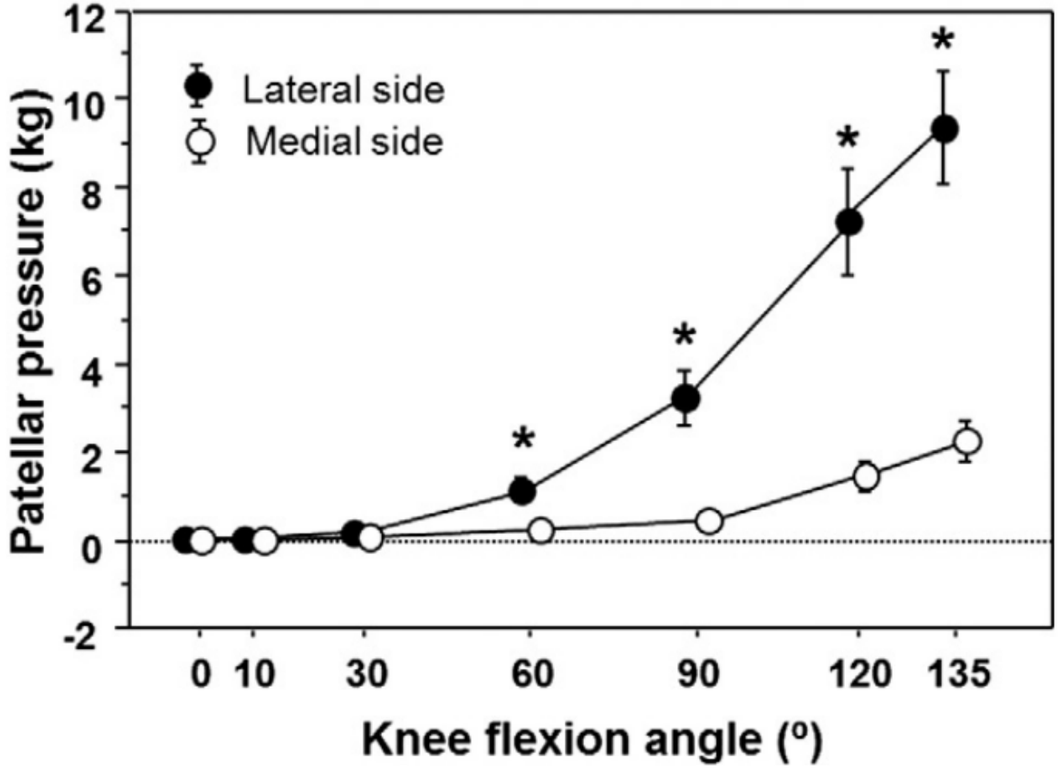

Compressive load increases on the lateral facet of the patella as knee flexion increases

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Correlation Between Knee Kinematics and Patellofemoral Contact Pressure in Total Knee Arthroplasty

Takuya Konno, MD [a], Tomohiro Onodera, MD, PhD [a], Yusuke Nishio, MD [a], Yasuhiko Kasahara, MD, PhD [a], Norimasa Iwasaki, MD, PhD [a], Tokifumi Majima, MD, PhD [b]

[a] Department of Orthopaedic Surgery, Hokkaido University Graduate School of Medicine, North 15 West 7, Kita-Ku, Sapporo Japan
[b] Department of Orthopedic Surgery, International Univ. of Health and Welfare Hospital, 537-3, Iguchi, Nasushiobara City, Japan

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ABSTRACT

The aim of this study is to evaluate the relationship between patellofemoral contact stress and intraoperative knee kinematic patterns after mobile bearing total knee arthroplasty (TKA). Medial osteoarthritic knees of forty-six posterior-stabilized total knee prostheses were evaluated using a computed tomography-guided navigation system. Subjects were divided into two groups based on intraoperative knee kinematic patterns: the medial pivot group (n = 18) and the non-medial pivot group (n = 27). Mean intraoperative patello-femoral contact stress was significantly lower in the medial pivot group than in the non-medial pivot group (1.7 MPa vs. 3.2 MPa, P < 0.05). An intraoperative medial pivot pattern results in reduced patello-femoral contact stress.

Total knee arthroplasty (TKA) has proven to be highly successful at alleviating pain and improving function in patients with advanced knee arthritis. As the indications of TKA have been widened, the demand for the procedure is increasing. Therefore, the number of revision TKAs is also rising, with a projected increase of 601% between 2005 and 2030 in The United States [1]. Patello-femoral problems are one of the common post-TKA complications and may result in revision surgery [2,3]. Several reports indicated that up to 12% of TKA revisions are due to patello-femoral dysfunction [2,4,5]. Various factors such as body mass index, patellar cartilage thickness, radiologically evident patello-femoral compartment osteoarthritis, and patellar tilt do not accurately predict patello-femoral dysfunction [6,7].

Five to 45% of post-TKA patients complain of residual anterior knee pain [8,9]. Patello-femoral complications have been attributed to errors in operative technique, inferior prosthetic design, components oversizing, and excessive patello-femoral loads. Several in vitro patellar resurfacing studies found a decrease in the retropatellar contact area, an increase in retropatellar pressure, and an increase in shear forces after resurfacing the patella [10,11]. However, the etiology of these complications with patellar resurfacing is yet to be clearly established [11,12]. Low patello-femoral pressure was considered to be advantageous because high pressures might account for anterior knee pain [12,13].

Large tibiofemoral kinematic variations, including the medial pivot [14,15] and the lateral pivot [16,17], are known to exist after conventional TKA. There is a wide variation in patellar kinematics associated with patello-femoral contact stress in the normal knee as well [18,19]. However, we have found no study of the relationship between tibiofemoral kinematic patterns after TKA and patello-femoral contact stress.

We hypothesized that tibiofemoral kinematic patterns after TKA will impact patello-femoral contact stress. The aim of this study was to evaluate the relationship between knee kinematics and patello-femoral contact stress in mobile bearing prosthesis with navigated TKA procedures.

Materials and Methods

One hundred and fifteen consecutive patients who had medial knee osteoarthritis were enrolled in this study. All knees had a Kellgren-Lawrence grade of 4 in the medial compartment and underwent a primary posterior stabilized mobile bearing total knee arthroplasty (PFC Sigma RP-F; Depuy, Warsaw, IN, USA) between May 2007 and October 2010. A computed tomography-guided navigation system (Vector Vision 1.6, Brain LAB, Heimstetten, Germany) was used for accurate implantation with a standardized navigated TKA technique for all cases. Surgeries were performed by a single surgeon using a subvastus approach to mitigate the influence of surgical approach to producing muscle balance. No patients received a lateral retinacular release. Approval for this experiment was obtained from our institutional investigational review board.

The Conflict of Interest statement associated with this article can be found at http://dx.doi.org/10.1016/j.arth.2014.07.020.

Reprint requests: Tokifumi Majima, MD, PhD, Department of Orthopedic Surgery, International Univ. of Health and Welfare Hospital, 537-3, Iguchi, Nasushiobara City, 329-2763, Japan.

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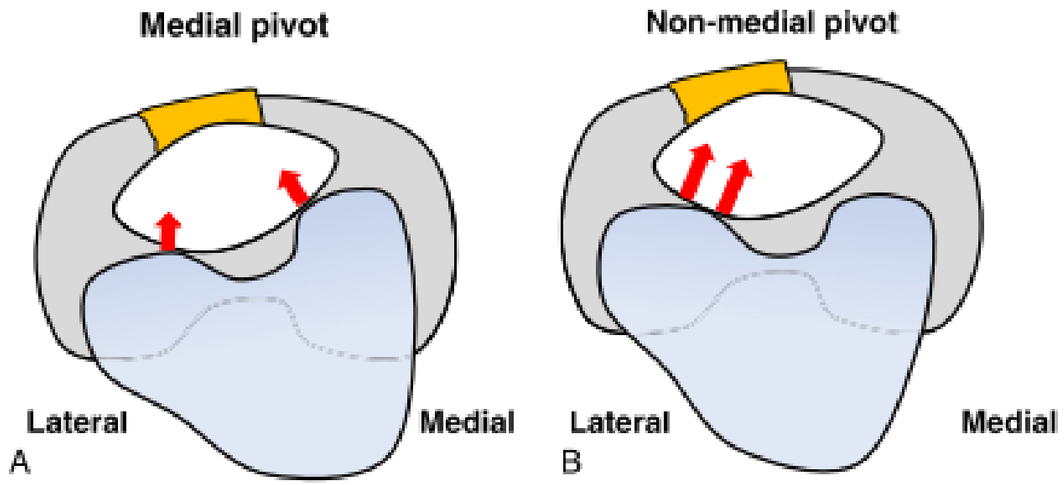


If the knee does not pivot medially, the lateral facet of the patella will remain heavily loaded, especially in deep flexion. This may be a cause of early patellar failure and ongoing anterior knee pain after total knee arthroplasty

Purpose

To examine the relationship between medial pivot mechanics and TT–TG offset before and after Functional KA total knee arthroplasty

Materials and Methods

- N=33
- Primary CR TKA with patellar resurfacing
- Enhanced optical navigation
- Functional KA technique

- Point to point measures made using the optical navigation system.
- System calculates distance in 3 orthogonal vectors based on registered sagittal, coronal and axial planes.
- Mediolateral measurements recorded from A to D, A to C where

A is the head of a small fragment screw giving a fixed point on the medial side of the knee

D is the most distal point of the central trochlea sulcus

C is the head of a small fragment screw in the centre of the Tibial Tuberosity

- Distance DC represents the TT–TG distance
- Distance DC = distance AC - distance AD

Assessment of Pivot

Tibia allowed to flex passively on the femur without any rotational constraint applied through the foot

Internal–external rotation recorded during movement (+ value equals internal rotation)

Pressure transducer track map in fluorescent green confirms differential rollback and true medial pivot rather than paradoxic rotation

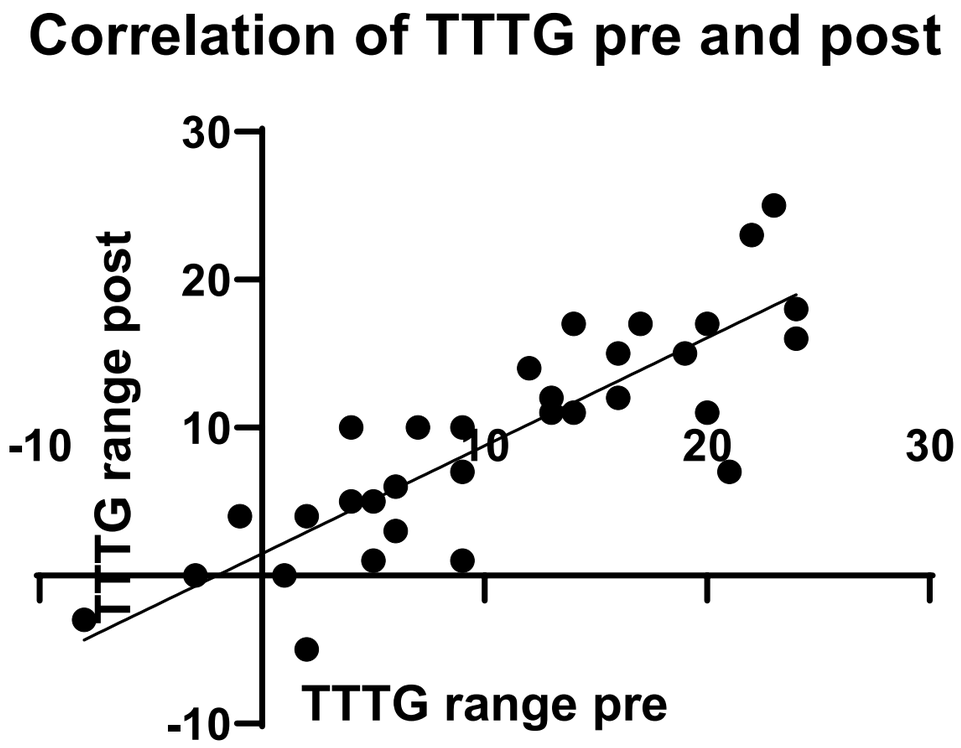
Analyze Initial Alignment

Record of Table

Table 1:

+	-	min						max
Flexion	Hyperextension	+9.5°	+0.0°	+30.0°	+45.0°	+60.0°	+90.0°	+126.0°
Valgus	Varus	-12.5°		-15.0°	-13.5°		-6.0°	-1.5°
Internal	External	-6.5°		-1.5°	+1.0°		+4.5°	+4.5°

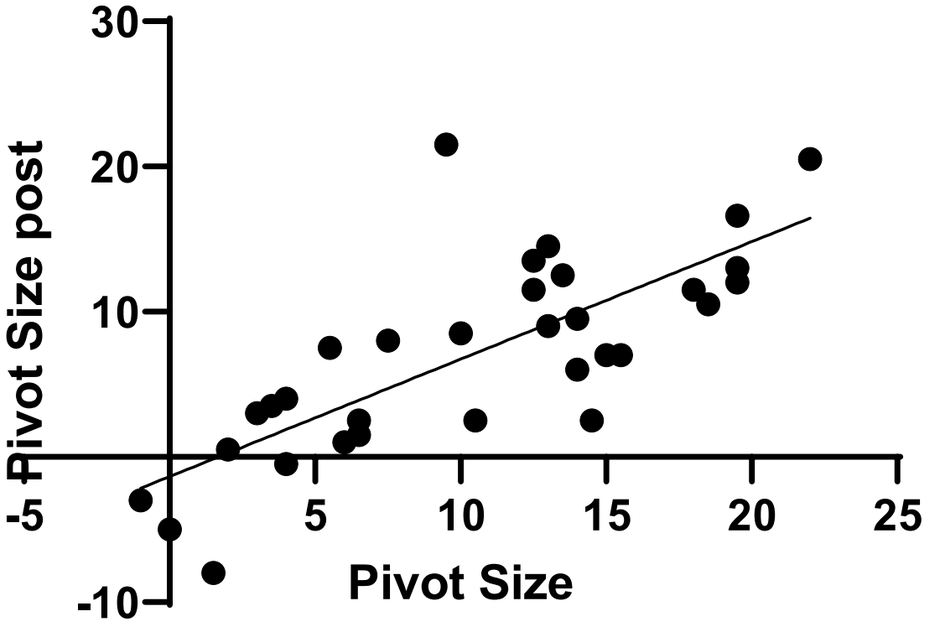
Results



Pearson r	
r	0.8485
95% confidence interval	0.7128 to 0.9229
R squared	0.7199
P value	
P (two-tailed)	<0.0001

A very strong correlation exists between TT–TG range in the native and post-implantation states

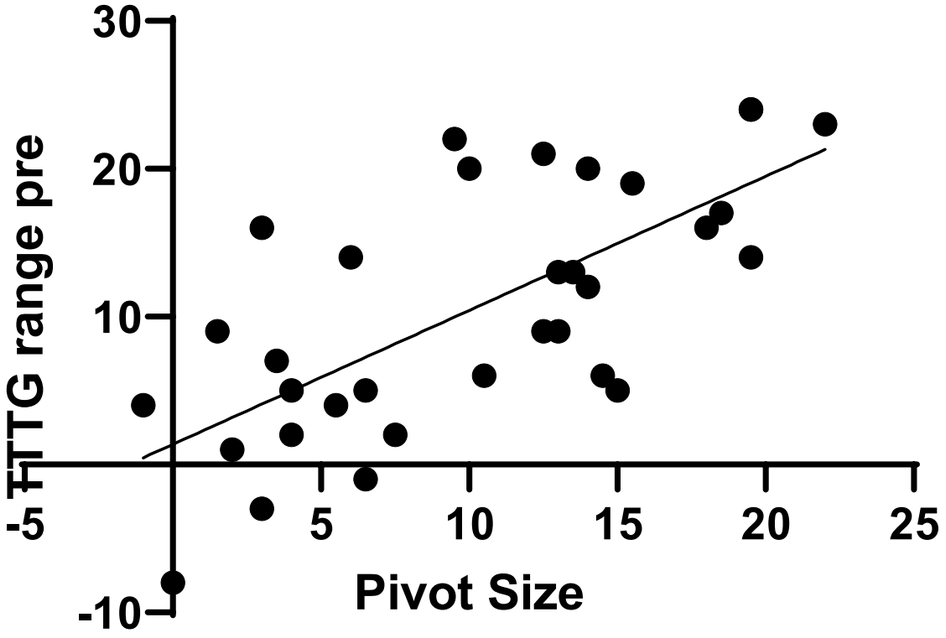
Correlation of Pivot pre and post



Pearson r	
r	0.7662
95% confidence interval	0.5738 to 0.8784
R squared	0.5870
P value	
P (two-tailed)	<0.0001

A strong correlation exists between the pivot range in the native and post-implantation states

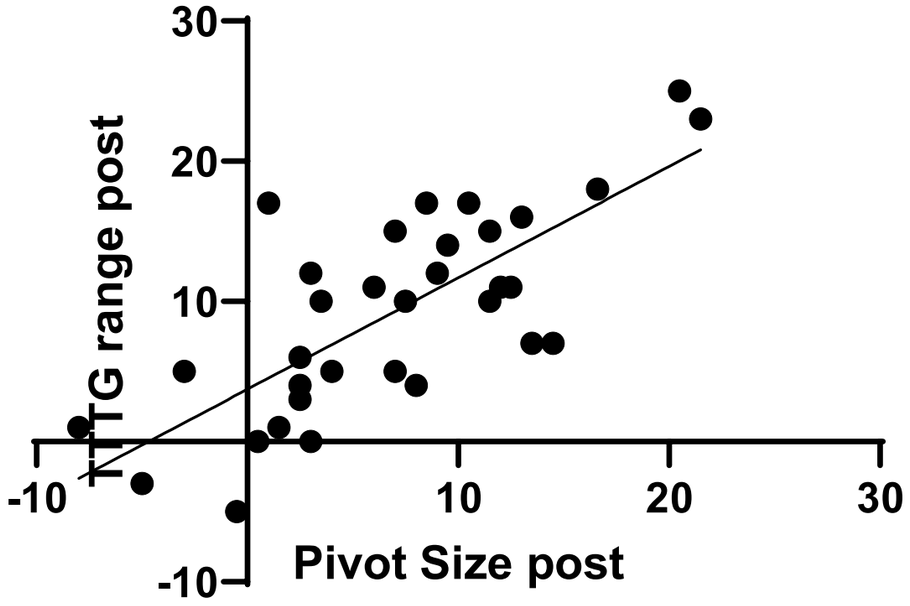
Correlation of Pivot Pre and TTTG pre



Pearson r	
r	0.6933
95% confidence interval	0.4594 to 0.8373
R squared	0.4807
P value	
P (two-tailed)	<0.0001

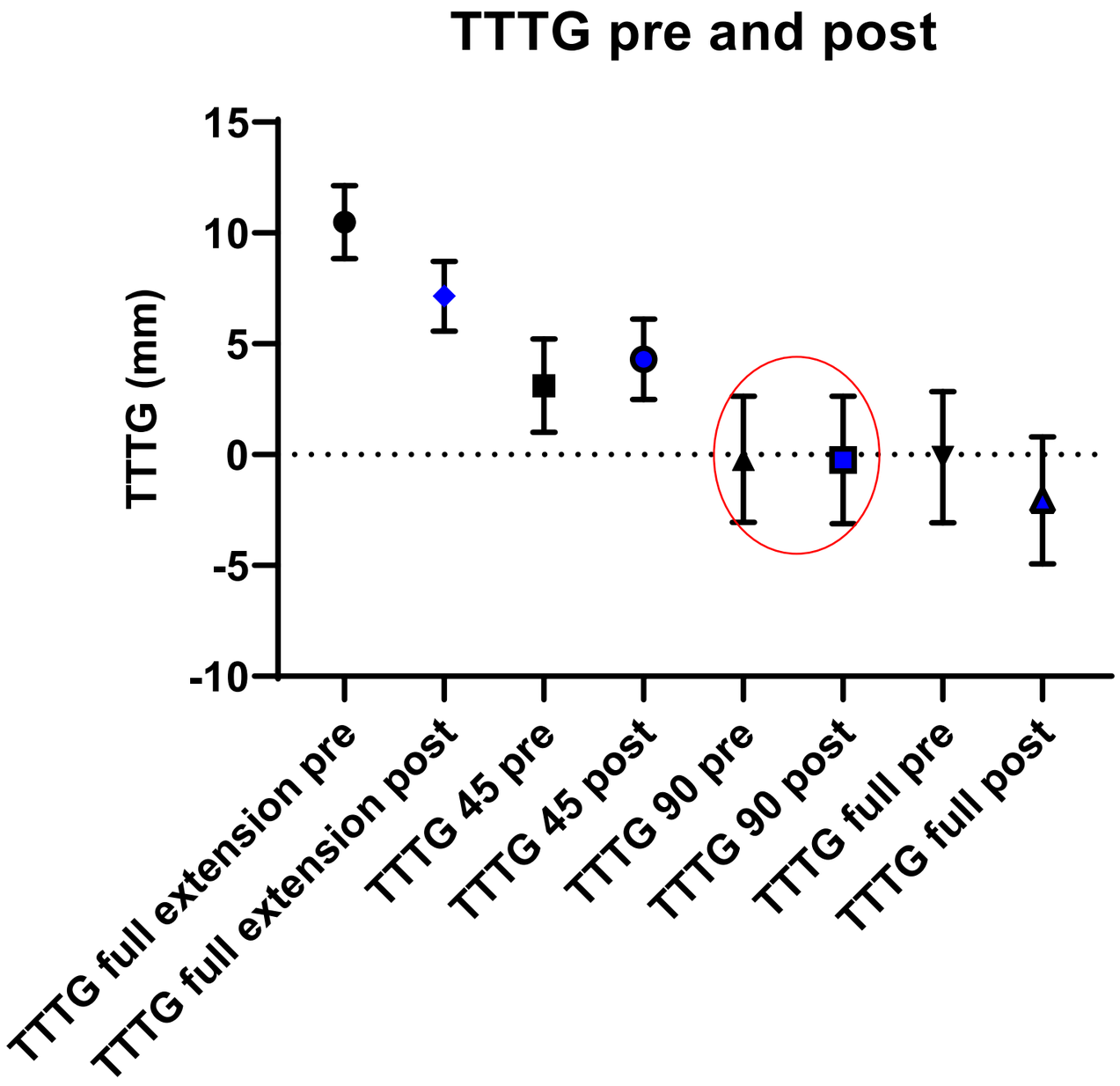
A strong correlation exists between the preoperative pivot range and the preoperative TT–TG range

Correlation of TTTG range post and pivot post



Pearson r	
r	0.7475
95% confidence interval	0.5437 to 0.8680
R squared	0.5588
P value	
P (two-tailed)	<0.0001

A strong correlation exists between knee post-operative pivot range and post-operative TT–TG range



In both native and post–implantation states the mean TT–TG offset is reduced to 0 mm

Conclusions

- Balanced Functional KA
- Largely restores preop TTTG and pivot
- TT-TG and medial pivot are strongly correlated before and after surgery
- TT-TG neutralises at 90 degrees knee flexion
- Next steps
  - Understand modifiable soft tissue and bony parameters that drive the pivot
  - Identify and correct unfavourable pivot mechanics