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Assessment of the utility of scanograms in primary total knee arthroplasty

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Abstract
Background and Objectives: Technological advancements in the field of knee arthroplasty is leading to an increased number of surgeries being performed every year. This upward trend is due to the aim of the operating orthopaedicians to achieve the most accurate limb alignment to thereby deliver improved functional outcome. Pre-operative assessment of limb alignment is done by two modalities commonly, scanograms and conventional radiographs. The current study was hence designed to evaluate, validate and compare these pre-operative assessment techniques in terms of their post-operative outcomes. Post-operative outcomes were assessed in different dimensions, namely post-operatively achieved limb alignment was analyzed using scanograms and the functional outcomes using specific outcome tools – WOMAC score and Oxford Knee score.
Methods: A total of 24 subjects (47 knees) were enrolled in the study as per the inclusion and exclusion criteria.
Results: The results obtained from our study indicate that despite better neutral alignment was achieved by the use scanograms, it did not provide any significant improvement in the functional outcome of our subjects.
Interpretation and Conclusion: The use of scanograms pre-operatively has little practical value and is an additional cost borne by the patient. More large scale, organized and sophisticated research needs to be done on the same, to enable its application in orthopedic surgery.

Keywords: Total knee arthroplasty, scanogram, osteoarthritis

Introduction
Our objective for total knee arthroplasty is to attain excellent alignment of the femoral, tibial, and patellar components, with complete restoration of the patient's lower extremity to neutral [1]. Adequate alignment of the knee is one of the most important factors in determining the long-term prognosis of TKA [2], and is considered to reduce both the mechanical and shear stresses imparted on the bearing surfaces and the bone/prosthesis interfaces [3, 4, 5]. While doing so, durability of the implant depends on restoration of neutral mechanical alignment [6, 7, 8, 9, 10, 11, 12, 13, 14]. Once neutral mechanical alignment is achieved, the mechanical axis of the leg then passes through the center of the knee, which leads to an even mediolateral distribution of the load, thus reducing the risk of implant wear out and component loosening [6, 7, 8, 13, 15]. Therefore, various techniques to obtain intraoperative restoration of mechanical alignment have been tried in the past, usually by taking intramedullary or extramedullary alignment rods as reference or using more sophisticated computerized navigation methods [12]. Moreover, adequate alignment helps in balancing the forces transmitted through the soft-tissues, which is crucial in functioning of the knee joint [22]. Hence, poorly aligned total knee arthroplasties can result in decreased implant life, increased wear and tear of the implant, along with poor functional outcome causing early failure (Seen with older polyethylene and implant designs).
Measured resection or gap balancing technique have been frequently used for achieving classical alignment in TKA. Contrarily, anatomic alignment in TKA needs to closely match the true anatomy of the femur and tibia to permit the joint line to be parallel to the ground during the normal stance phase of gait.

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Better replication of the neutral mechanical axis of the knee by recent technological advancements, including computer navigation and patient- specific instrumentation has been of great help to the surgeon. However, despite the improved radiographic alignment and fewer axis derangements, these innovations have not necessarily delivered improved outcomes clinically.

During normal gait, motion of the knee has been extensively researched revealing it to be more complex than simply, flexion and extension. Motion of the knee joint during gait occurs in all -flexion and extension, abduction and adduction, and rotation around the along axis of the limb. The articular geometry and the ligamentous restraints around the knee joint causes knee flexion to occur around a varying transverse axis. Dennis *et al.* states that the of flexion axis in a normal knee varies in a helical fashion (average of 2 mm posterior translation of the medial femoral condyle on tibia during flexion as compared to 21mm of translation of lateral femoral condyle). This has been studied by dynamic 3D-fluoroscopic CT scan of knee. After sectioning of anterior cruciate ligament, the axis become variable, causing an average 5mm of medial condylar translation and 17mm of lateral condylar posterior translation in flexion. The early knee prosthesis designs were unable to accommodate these complex knee movements, thus causing implant failure. An important aid in prosthesis design and evaluation is the use of gait laboratories, to study normal subjects before and after TKA.

Kinematic study of knee joint during normal gait reveals which the knee requires

Degree of Flexion	Motion
67 degrees	Swing phase
83 degrees	Stair climbing
90 degrees	Descending stairs
93 degrees	Rising from a chair

The anterior posterior (AP) radiograph of knee has been considered as gold standard for the determination of knee alignment, serving as the bases for planning a TKA.
- In cases of advanced osteoarthritis and severe varus deformity of the knee in the standing position, often shows an increase in the lateral joint space, due to relative laxity of the lateral collateral structures and attrition of the medial articular surfaces.

Accurate restoration of the mechanical axis (MA) of the limb, appropriate alignment of the components and adequate balancing of the soft tissue are all vital parameters for the long-term success of total knee arthroplasty (TKA).

Material and Methods
The methodology followed for the purpose of this study is described below –
Ethics – The study commenced after obtaining adequate permission from the Institutional Ethics Committee of Dr. D. Y. Patil Medical College, Hospital and Research Centre, Nerul, Navi Mumbai, Maharashtra, India. All patients were explained the purpose and rationale of the study. They were also explained their role as participants in the study. Written informed consent was obtained from all the patients prior to their enrolment in the study.
Study Site – This Prospective study was conducted in the Department of Orthopaedics, Dr. D. Y. Patil Medical College, Hospital and Research Centre, Nerul, Navi Mumbai.
Study Population – This prospective study was conducted on 24 patients (47 knee joints) who were scheduled to undergo surgery for osteoarthritis of knee joint. The patients of age 30 years and above, either sex with osteoarthritis of the knee were included in this study. All patients were briefed about the purpose of this study and their written, valid and informed consent for the surgery was taken.

Imaging techniques
Alignment in a conventional radiograph
- A conventional radiograph consisted of weight-bearing antero-posterior (AP) radiographic view of the knee joint.
- Standard measurement of file - 24x30cm, obtained
- Radiographs were obtained at a focus film distance of 1m.
- All radiographs were obtained with a consistent technique – with the patients standing on both legs with medial aspect of their feet parallel to each other, with knees in full extension.
- The knee AP radiograph was centered at the lower part of patella.
- The tibial femoral angle were evaluated from both radiographs.
- Angles were calculated through digital software

Limb, knee and component alingment in a scanogram
Using standardized protocol, antero-posterior (AP) scanograms of the lower limb were obtained to determine the coronal alignment of the limb, knee and components.
Mechanical Axis Angle (MA angle)/ Hip Knee Ankle Angle (HPA angle) – The MA angle was calculated according to Hagsted and Colleagues.
- The center of the femoral head was the center of a circle fit to the articular surface of the femoral head.
- The center of the knee joint is the distal end of the femoral component or condyle at the level of the top of the intercondylar notch.
- Centre of the ankle is at the proximal end of talus.
- A line was drawn from the center of rotation of femoral head to the center of knee on the distal femur and connected by another line, drawn from the center of the proximal tibia to the mid-point of talar dome of distal tibia.
- The hip-knee-ankle angle was measured in the coronal plane as the angle between the femoral coronal mechanical axis and tibial coronal mechanical axis.
- A valgus alignment was given a positive value (+).
- A varus alignment was given a negative value (-).
- HKA was considered satisfactory, if it deviated 3 degrees or less from neutral alignment.

Mechanical Lateral Distal Femoral Angle–It is the angle formed between the mechanical axis of femur and the joint orientation line of distal femur.
Anatomic Lateral Distal Femoral Angle–It is the angle formed between the anatomic axis of femur and the joint orientation line of distal femur.
Medial Proximal Tibial Angle–It is the angle formed between the anatomic/mechanical axis of tibia and the joint orientation line of proximal tibia.
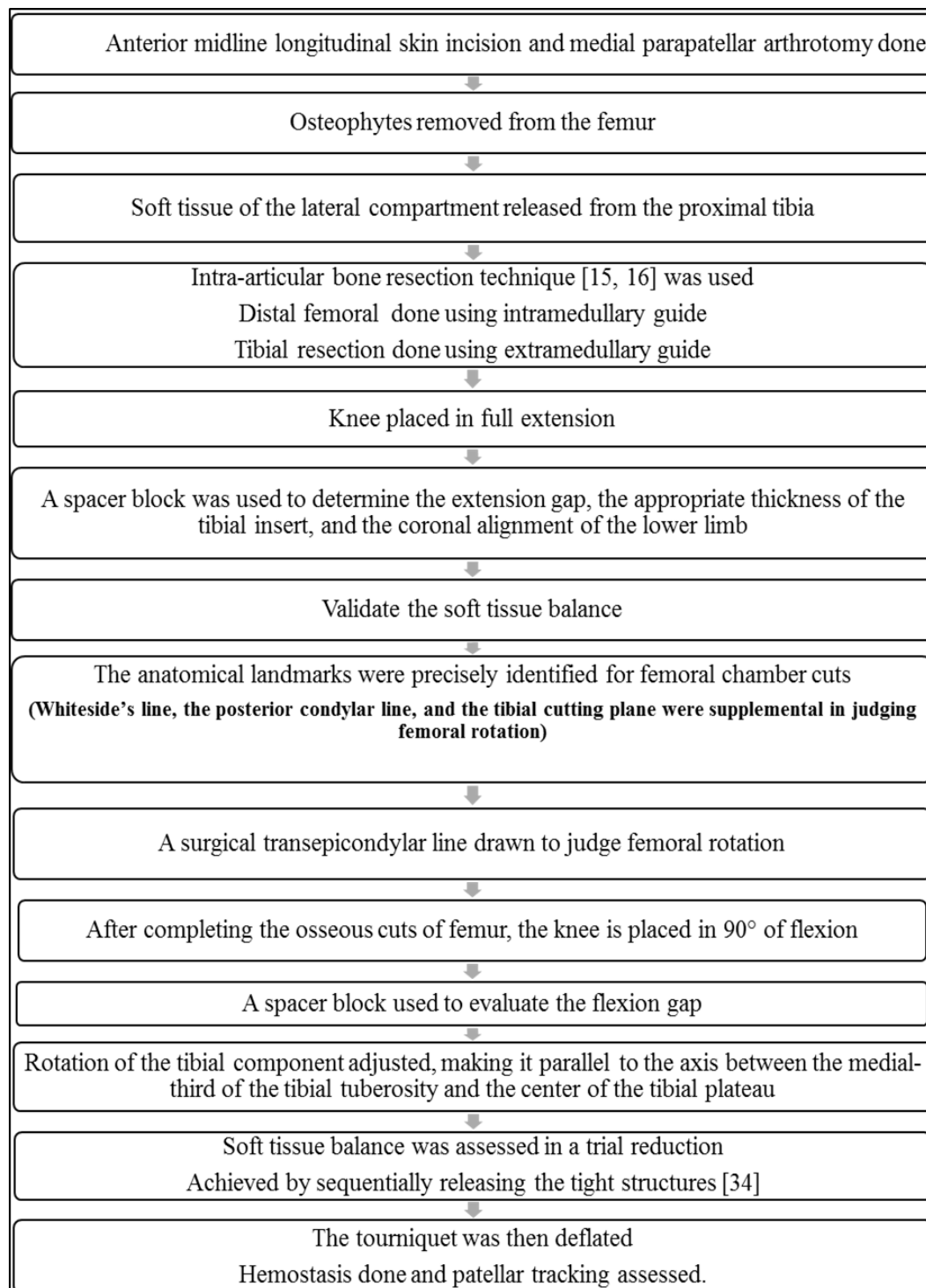
Inclusion criteria
- Age above 30.
- No history of any surgical treatment around the knee joint.

- Consenting patients.
- Varus deformity of knee.
- No history of trauma
- Refractory to conservative treatment

- Valgus deformity.
- Non-consenting patient.
- Infection.
- Congenital deformity.
- Previous history of operation (Osteotomy, arthrotomy).

Exclusion criteria

Surgical Technique

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┌─────────────────────────────────────────────────────────────────────┐
│ Anterior midline longitudinal skin incision and medial parapatellar arthrotomy done │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ Osteophytes removed from the femur                                    │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ Soft tissue of the lateral compartment released from the proximal tibia │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ Intra-articular bone resection technique [15, 16] was used            │
│ Distal femoral  done using intramedullary guide                       │
│ Tibial resection done using extramedullary guide                      │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ Knee placed in full extension                                         │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ A spacer block was used to determine the extension gap, the appropriate thickness of the │
│ tibial insert, and the coronal alignment of the lower limb            │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ Validate the soft tissue balance                                      │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ The anatomical landmarks were precisely identified for femoral chamber cuts │
│ (Whiteside's line, the posterior condylar line, and the tibial cutting plane were supplemental in judging │
│ femoral rotation)                                                     │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ A surgical transepicondylar line drawn to judge femoral rotation      │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ After completing the osseous cuts of femur, the knee is placed in 90° of flexion │
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                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ A spacer block used to evaluate the flexion gap                       │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ Rotation of the tibial component adjusted, making it parallel to the axis between the medial- │
│ third of the tibial tuberosity and the center of the tibial plateau   │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ Soft tissue balance was assessed in a trial reduction                 │
│ Achieved by sequentially releasing the tight structures [34]          │
└─────────────────────────────────────────────────────────────────────┘
                                    ↓
┌─────────────────────────────────────────────────────────────────────┐
│ The tourniquet was then deflated                                      │
│ Hemostasis done and patellar tracking assessed.                       │
└─────────────────────────────────────────────────────────────────────┘
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Sample size: The sample size based on the minimum sample size required for statistical significance. The final sample size for this study was 47knees (27 patients) for satisfying the null hypothesis.

Study duration: The study was conducted from July 2014 to June 2016 in Department of Orthopedics, Dr. DY Patil Medical College, Hospital and Research Centre, Nerul, Navi Mumbai.

Study procedure: Following information was collected from each patient enrolled in the study, and was recorded on a Case Record Form (CRF).

Data collection method: The study was on subjects undergoing Total Knee Arthroplasty (TKA) for knee arthritis

with pre-operative evaluation by either scanogram or conventional radiograph, followed by post-operative scanogram evaluation and functional outcome evaluation at 2 months. All patients who underwent the operation were followed-up according to the evaluation.

Clinical evaluation
Subjective: A detailed questionnaire was completed with each patient to evaluate subjective factors such as pain, functional limitations and occupational considerations.

Objectives: Objective examination was include inspection of the knee joint for deformity, tenderness, abnormal mobility, measurement of range of movements extending from hip to ankle, any previous scare marks around knee, discharging sinus or any other signs of infection.

Radiological evaluation
Includes evaluating grades of arthritis/to rule out fractures or tumors around the knee/assess amount of ligament laxity/measuring angles around the knee joint.

Functional evaluation
1. Knee Range of movements.
2. Stiffness of knee.
3. Pain while doing routine activities.
4. Ability to do day to day activities.

Follow up Schedule - 6 weeks.

Clinical assessment
- Patients were assessed for pain, deformity, tenderness, range of motion, stiffness and signs of infection.
- Weight bearing scanogram was taken at 6 weeks to assess various angles and radiological outcomes.
- The range of motion was compared using a Goniometer.
- Patients were observed for complications such as blood loss, intra-operative fractures, wound infection, deep vein thrombosis and other early /late complications.

Evaluation of results
Results were assessed using
1. **Functional assessment:** Done by comparing range of motion (Using goniometer) and scoring system (Oxford Knee Score, WOMAC Score) were used to asses various modalities from pain, stiffness and ability to perform daily activities.
2. **Radiological assessment:** Done by calculation of Mechanical Axis angle (HKA angle), Mechanical Lateral

Distal Femoral Angle (mL DFA), Anatomic Lateral Distal Femoral Angle (aL DFA), Mechanical/Anatomic Proximal Tibial Angle (MPTA) and its comparison with normal values of that particular angle.

Method of statistical analysis
- Baseline study participant characteristics were described using descriptive statistics.
- Parametric data if it passes the tests of normality were analyzed using parametric tests or else non-par ametric tests were used for its analysis.
- Categorical data were analyzed using Chi-square test.
- Parametric correlat ion analysis were done using Pearson correlation test while non-parametric correlation analysis were done using Spearman correlation test.

Results
Sample Size–24 patients (47 knees)
Divided into –
Group A–24 knees (With pre-operative scanograms)
Group B–23 knees (With pre-operative conventional radiographs)
1. Age - For 24 patients enrolled in the study, the mean age was found to be 60.85 ± 9.63 years.
2. Age with respect to gender - For 24 patients enrolled in the study, mean age for women was 57.72 ± 6.48 years and for mean was 65.89 ± 11.77 years.
3. Gender - In our study, 61.7% sample size consisted of females and 38.3% of males.
4. Weight (in kgs) - In our study, mean weight of our patients was 72.64 ± 7.52 kgs.
5. Height (in cms) - In our study, mean height of our patients was 165.77 ± 6.7 cm.
6. Grade of arthrosis - According to Kellgren and Lawrence classification, the mean grade of arthrosis of our patients was 3.26 ± 0.57.
7. WOMAC score comparison

Table 1: Score

	Group A		Group B	
	Pre-OP	Post-OP	Pre-OP	Post-OP
Womac Score	77.24 (5.78)	79.46 (5.35)	78.20 (5.95)	80.69 (5.57)
Individual P value	0.034 (S)		0.022 (S)	
P value on comparison	0.61 (NS)			

P value is calculated by paired T test.

In our study, WOMAC score improved post-operatively in both the groups individually.
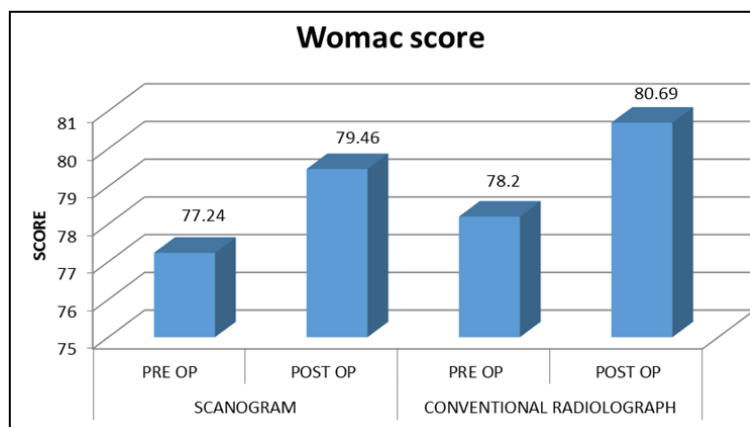On comparison with each other, the P value is insignificant.

**Fig 1:** Womac Score

8. Oxford knee score comparison

Table 2: Oxford knee score

	Group A		Group B	
	Pre-op	Post-op	Pre-OP	Post-op
Oxford Knee Score	33.29 (3.32)	35.38 (2.83)	33.65 (3.23)	36.00 (2.68)
Immediate P value	0.045 (S)		0.034 (S)	
P value on comparison	0.55 (NS)			

In our study, Oxford Knee score improved post-operatively in both the groups individually.

On comparison with each other, the P value is insignificant.
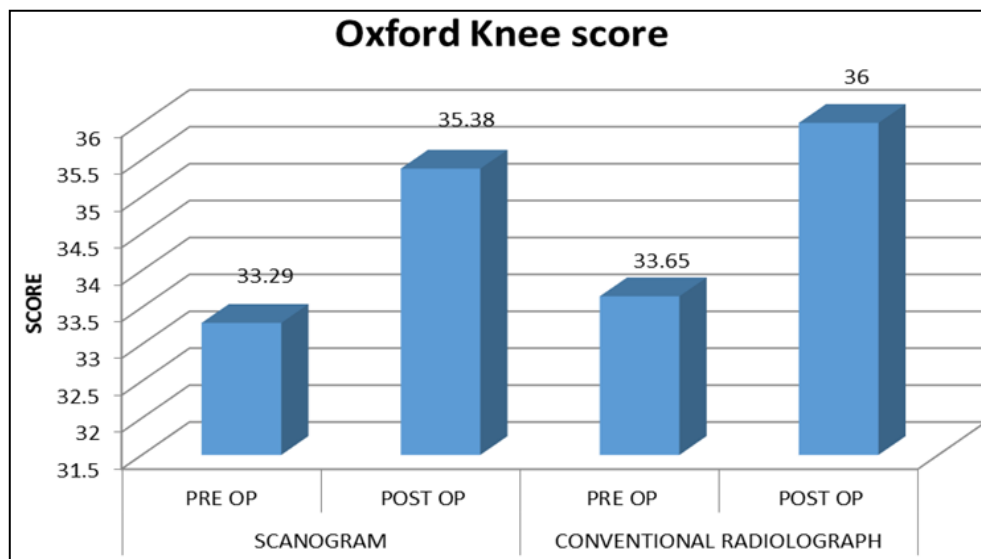
Fig 2: Oxford knee score

9. Comparison of anatomic lateral distal femoral angle (aLDFA)

Group A

Table 3a: LDFA (Group A)

	Pre-Operative aL DFA	Post-Operative aLDFA	P value = 0.539 (NS); T Test
Mean	82.60	82.92	
Standard Deviation	2.24	1.29	

Group B

Table 4a: LDFA (Group B)

	Pre-Operative aLDFA	Post-Operative aLDFA	P VALUE = 0.836 (NS); T Test
Mean	82.64	82.77	
Standard Deviation	2.72	1.41	

[Normal Range – aLDFA=79-83 degrees]

10. Comparison of medial proximal tibial angle (MPTA)

Group A

Table 5: MPTA (Group A)

	Pre-Perative MPTA	Post-Operative MPTA	P Value = 0.043(S); T test
Mean	84.13	86.04	
Standard Deviation	3.83	2.31	

Group B

Table 6: MPTA (Group B)

	Pre-Operative MPTA	Post-Operative MPTA	P Value = 1.00(NS); T Test
Mean	84.33	84.83	
Standard Deviation	3.43	3.43	

[Normal Range – MPTA=85-90 degrees.]

Scatter diagram reprentative of post-operative mechanical axis (MA) angle alignment of both the groups
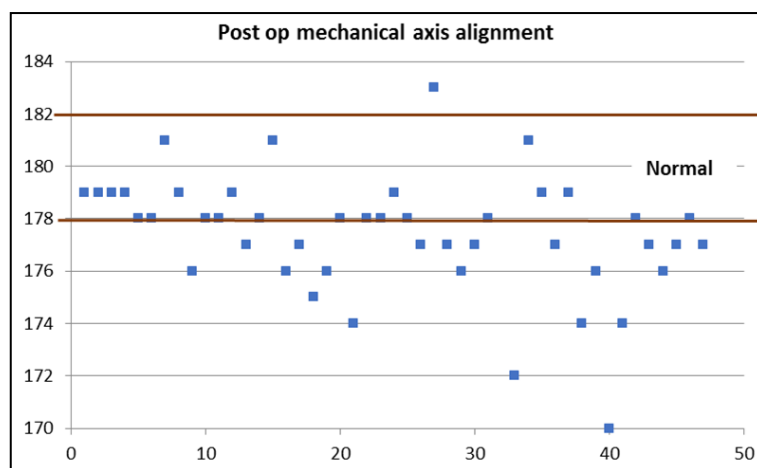
Fig 3: Post op mechanical axis alignment

[Normal range - MA angle=180+/-3 degrees]

12. Comparison of post-operative mechinaical axis (MA) angle alignment of both groups
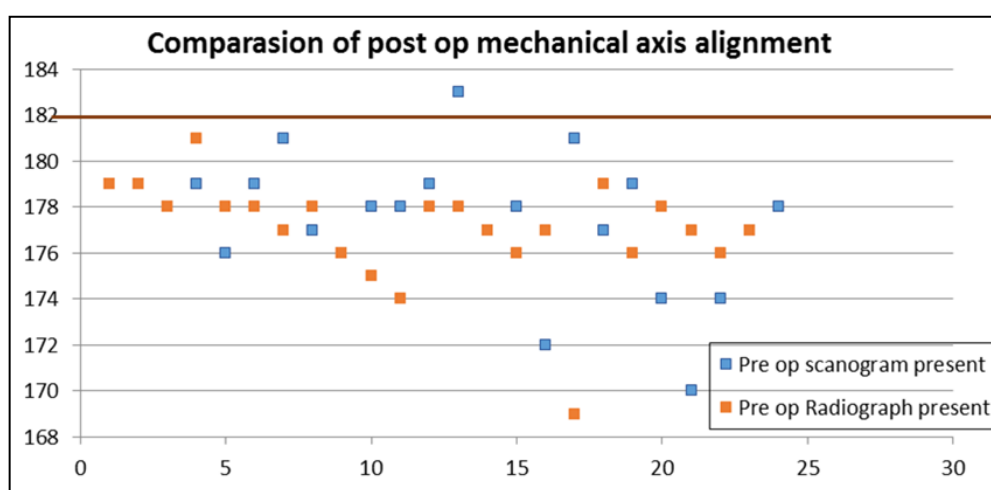

Fig 4: Comparision of post op mechanical axis alignment

Discussion
This prospective randomized case control study was designed to correlate the functional and radiological outcome in patients undergoing TKA by using different pre-operative modalities.
A sample size of 27 patients (47 knees) were selected who were scheduled to undergo TKA. They were divided into 2 groups – Group A had patients with pre-operative scanograms (24 knees) and Group B had patients with pre-operative conventional radiograph (23 knees).
All knees were operated by a single experienced surgeon by the conventional technique using intra-medullary and extra-medullary jigs.
A detailed questionnaire was completed with each patient of both the groups to determine the pre-operative Womac Score and Oxford Knee Score. Both these scores evaluated subjective factors such as pain, joint stiffness, functioning disability and inability to perform daily activities. Objective examination included inspection of the knee joint to rule out deformity, tenderness and signs of infection. Range of motion (ROM) from hip to ankle was also assessed.
In case of scanograms, mechanical axis (MA) angle, mechanical lateral distal femoral angle (mLDFA), anatomic lateral distal femoral angle (aLDFA) and medial proximal tibial angle (MPTA) were calculated.
In case of conventional radiographs, anatomic lateral distal

femoral angle (aLDFA) and medial proximal tibial angle (MPTA) were calculated.
Pre-operative results of both the groups was compared to the results obtained from their post-operative scanograms at 2 months.
In our study, 23 subjects underwent bilateral TKA. We did not separately address the outcomes of patients undergoing bilateral TKAs from whose who underwent unilateral surgery. However, we have conducted separate analyses by number of patients and number of knees operated.
No major perioperative or intra-operative complications were encountered to hamper the post-operative functional outcome. Each patient was proactively followed up for 2 months to avoid attrition bias in our study.
The mean age was found to be 60.85+/- 9.63 years. A study conducted by Anna Litwic in January, 2013 calculating the age specific incidence of knee arthritis, the mean age was found to be 60+/- 7 years, to which are our findings are comparable.
Age with respect to gender evaluation showed mean age for development of osteoarthritis for women was 57.72+/-6.48 and for men was 65.89+/-11.7. The above mentioned study by Anna Litwic found out similar results for mean age of women being 55+/-5 and for women 64+/-5.
In our study, male to female ratio for prevalence of knee osteoarthritis is 0.6:1 indicative of female preponderance to

knee osteoarthritis. This finding correlates with the study conducted by Anna Litwic.

The mean weight was found to be 72.64+/-7.52 and the mean height was found to be 165.77cm with standard deviation of 6.7. Hence, this suggests that increased weight and height can possibly lead to increased chances of osteoarthritis.

None of the studies provided information regarding racial/ethnic status.

The frequency of knee osteoarthritis continues to accelerate, most likely because of the aging of the population and the increasing proliferation of the primary risk factor, obesity.

Grading of arthrosis in our study was done according to Kellgren and Lawrence Classification and mean grade was found to be 3.2. The Framingham Osteoarthritis Study showed similar results

While conducting our study we standardized projection of the extremity, by positioning the flange in a way such that it lies in between the medial and lateral condyles of the femoral component. This limited malrotation of the knee

Joint orientation angles such as Anatomic Lateral Distal Femoral Angle (mLDFA) and Medial Proximal Tibial Angle (MPTA) are seen in both scanograms and conventional radiographs. Comparison of these angles was done both pre- and post-operatively.

Our findings were

Post-operative aLDFA (mean) using scanograms – 82.92.

Post-operative aLDFA (mean) using conventional radiographs – 82.77.

Post-operative MPTA (mean) using scanograms – 86.04.

Post-operative MPTA (mean) using conventional radiographs – 84.83. [Normal Range – aLDFA=79-83 degrees, MPTA=85-90 degrees.]

This shows that better joint orientation angles were achieved post-operatively using scanograms.

To evaluate limb alignment in both groups, mechanical axis (MA) angle was compared pre-operatively in group A and post-operatively in both the groups. Normal range of MA angle=180+/-3.

Out of 47 operated knees, 24 knees achieved the normal range of MA angle, 13 knees from Group A and 11 knees from Group B.

This suggests that pre-operative evaluation of MA angle did not provide us any additional benefit over pre-operative radiologic evaluation of joint orientation angles.

With the help of outcome tools, namely WOMAC score and Oxford Knee score we assessed functional outcome of patients of both groups, both pre- and post-operatively at 2 months. The functional outcome post-operatively for group A was Pvalue=0.034 and for group B was Pvalue=0.022, both groups delivering improvements.

On comparison of both groups with each other, P value was found to be 0.61, which is non-significant. Hence, despite both investigative measures, namely, scanograms and conventional radiograph showed significant improvement in function singularly, but on comparison with each other, the difference in functional outcomes was found to be insignificant.

Similar result was found on application of Oxford Knee score too, wherein post-operative functional outcome for Group A was Pvalue=0.045 and for Group B was Pvalue=0.034, showing improvement in both groups respectively. But on comparison with each other the P value was found to be 0.55, which is non-significant.

This goes to shows that both mechanically and anatomically aligned knees gave improved functional outcome post-operatively

Summary and Conclusion

This was a prospective randomized case control study conducted on patients scheduled to undergo total knee arthroplasty for osteoarthritis of the knee joint. This study was designed to assess the efficacy of pre-operative scanograms in TKA and to validate the improvement in post-operative functional outcome by their use.

Our study had a sample size of 24 patients (47 knees) with the mean age of 60.85+/- 9.63 years (Women - 57.72+/-6.48 and men - 65.89+/-11.7), mean height of 165.77+/-6.7, mean weight of 72.64+/-7.52 with the mean grade of arthrosis of 3.24+/-0.57.

All patients underwent TKA by the conventional technique by a senior orthopaedician.

Pre- and post-operative functional outcome was evaluated using specific outcome tools, namely WOMAC and Oxford Knee Score, in all patients.

Patients were divided in 2 groups, group A – Patients with pre-operative scanograms and group B – Patients with pre-operative conventional radiograph. Both set of patients were evaluated post-operatively radiologically by scanograms and clinically by outcome tools – WOMAC score and Oxford Knee score.

Individually, both groups showed improved radiological and functional outcomes post-operatively.

On comparison with each other, radiologically, Group A delivered better alignment, but the difference is insignificant. Group A had 13 out of 24 knees and Group B had 11 out of 23 knees which attained neutral alignment post-operatively. Similar alignment trend was also seen on comparison of joint orientation angles.

Functionally, no statistical difference in the outcomes tools was encountered (p value = 0.61).

The use of scanograms did help us achieve better neutral alignment of the limb but it did not significantly improve the functional outcome post-operatively. Hence, its pre-operative use has little practical value.

Despite the limitations of, primarily, small sample size and inability for long term post-operative follow-up, we have made our best attempt to unravel the mystery of optimum alignment in TKR.

More sophisticated and large scale analysis needs to be conducted on the same, keeping the primary aim of a surgeon, that is, improve functional outcome and patient satisfaction, high in priority.

References
1. Blumenfeld TJ. CORR Insights (R): is TKA using patient-specific instruments comparable to conventional TKA? A randomized controlled study of one system. Clin Orthop Relat Res. 2013; 471:3996. Doi: 10.1007/s11999-013-3283-1.
2. Barrett WP, Mason JB, Moskal JT, Dalury DF, Oliashirazi A, Fisher DA. Comparison of radiographic alignment of imageless computer-assisted surgery vs conventional instrumentation in primary total knee arthroplasty. J Arthroplasty.
3. D'Lima DD, Chen PC, Colwell CW, Jr Polyethylene contact stresses, articular congruity, and knee alignment. Clin Orthop Relat Res. 2001; 392:232. Doi: 10.1097/00003086-200111000-00029. [PubMed] [Cross Ref]
4. Pickering S, Armstrong D. Focus on alignment in total

knee replacement. J Bone Joint Surg. 2012. http://www.boneandjoint.org.uk/content/focus/alignment-total-knee-replacement. Accessed 15 Jan 2014.

5. D'Lima DD, Hermida JC, Chen PC, Colwell CW., Jr Polyethylene wear and variations in knee kinematics. Clin Orthop Relat Res. 2001; 392:124. Doi: 10.1097/00003086-200111000-00015. [PubMed] [Cross Ref]

6. Aglietti P, Buzzi R. Posteriorly stabilized total-condylar knee replacement: three to eight years' follow-up of 85 knees. J Bone Joint Surg Br. 1988; 70:211-216.

7. Benjamin J. Component alignment in total knee arthroplasty. Instr Course Lect. 2006; 55:405-412.

8. Ang DM, Ritter MA, Davis KE. Coronal alignment in total knee arthroplasty: just how important is it? J Arthroplasty. 2009; 24(6):39-42. Doi: 10.1016/j.arth.2009.04.034.

9. Hueter C. Anatomische Studien an den Extremitatengelenken Neugeborener und Erwachsener. Virchow Arch Pathol Anat. 1862; 26:484-519.

10. Jenny JY, Boeri C, Ballonzoli L. Coronal alignment of the lower limb. Acta Orthop. 2005; 76:403-407.

11. Lotke PA, Ecker ML. Influence of positioning of prosthesis in total knee replacement. J Bone Joint Surg Am. 1977; 59:77-79. [PubMed]

12. Rauth MA, Mihalko WM, Krackow KA. Optimizing alignment. In: Bellemans J, Ries M, Victor J, editors. Total Knee Arthroplasty: A Guide to Better Performance. 1. Heidelberg, Germany: Springer-Verlag. 2005, 165-169.

13. Ritter MA, Faris PM, Keating EM, Meding JB. Postoperative alignment of total knee replacement: Its effect on survival. Clin Orthop Relat Res. 1994; 299:153-156. [PubMed]

14. Sikorski JM. Alignment in total knee replacement. J Bone Joint Surg Br. 2008; 90:1121-1127. [PubMed]

15. Bargren JH, Blaha JD, Freeman MA. Alignment in total knee arthroplasty: correlated biomechanical and clinical observations. Clin Orthop Relat Res. 1983; 173:178-183.