

**A Comparative Study between the
Standard AO Method and Fibula Length
Measurement in Estimating Maximum
Femoral Nail Length**

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**DISSERTATION SUBMITTED IN PARTIAL
FULFILLMENT OF THE REQUIREMENT FOR
THE DEGREE OF MASTER OF MEDICINE
(ORTHOPAEDICS)**



UNIVERSITI SAINS MALAYSIA

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**A Comparative Study between the
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FROM THE YEAR 2020 TO 2021

STUDY VENUE: HOSPITAL UNIVERSITI SAINS
MALAYSIA

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ABSTRAK

Pengenalan

Patah tulang ‘femur’ adalah masalah biasa dalam bidang ortopedik dan dirawat secara rutin dengan besi intramedular. Kesesuaian panjang dan saiz besi intramedular perlu diukur sebelum pembedahan. Anggaran panjang maxima saiz besi intramedular ‘femur’ boleh diukur secara klinikal atau radiografi pada tulang ‘femur’ kontralateral atau dengan menggunakan perujukan lengan bawah. Walau bagaimanapun, kaedah ini tidak sesuai digunakan apabila pesakit patah kedua dua tulang ‘femur’ bersama dengan patah lengan bawah dengan serentak. Tujuan kajian ini adalah untuk mengenal pasti satu lagi kaedah klinikal yang boleh digunakan dalam menganggar kepanjangan maksimum besi intramedular tulang ‘femur’.

Kaedah Kajian

Sejumlah 140 pesakit yang hadir ke klinik dan wad ortopedik di Hospital Universiti Sains Malaysia (HUSM) serta memenuhi kriteria kemasukan dan pengecualian telah dipilih secara teknik persampelan mudah dan mengambil bahagian dalam kajian ‘cross sectional’ ini. Tulang ‘femur’ dan tulang ‘fibula’ mereka diukur menggunakan pita pengukur. Tulang ‘femur’ diukur mengikut kaedah standard AO manakala tulang ‘fibula’ diukur dari hujung kepala tulang ‘fibula’ ke hujung malleolus sisi. Data ini dikumpul dan dianalisis menggunakan SPSS versi 26. Statistik deskriptif digunakan untuk merumuskan ciri sosio-demografi subjek. Data berangka dibentangkan sebagai min (SD) atau median (IQR) berdasarkan taburan normalitinya, manakala data kategori dibentangkan sebagai kekerapan (peratusan).

Keputusan

Daripada 140 pesakit yang diukur, purata keseluruhan kepanjangan tulang ‘femur’ yang diukur ialah 37.98 cm dengan sisihan piawai sebanyak 2.72 cm manakala kepanjangan tulang ‘fibula’ ialah 37.72 cm dengan sisihan piawai sebanyak 2.61 cm. Analisis Korelasi Pearson menunjukkan bahawa panjang tulang ‘fibula’ sangat berhubungkait dengan panjang tulang ‘femur’ dan hubungan ini tidak dipengaruhi oleh umur, BMI atau jantina. Korelasi Interclass (ICC) menunjukkan tahap kebolehpercayaan antara pemerhati dan intra-pemerhati yang tinggi dilihat dalam kedua-dua ukuran tulang ‘femur’ (ICC 0.938 dengan 95% kepercayaan) dan ‘fibula’ (ICC 0.972 dengan 95% kepercayaan). Formula anggaran kepanjangan maxima besi intramedula ‘femur’ diperolehi daripada graf korelasi.

$$\begin{aligned} &\text{kepanjangan maxima besi intramedula ‘femur’} \\ &= 1 + (0.98 \times \text{kepanjangan tulang ‘fibula’}) \end{aligned}$$

Kesimpulan

Kepanjangan tulang ‘fibula’ ditunjukkan berhubungkait dengan baik dengan kepanjangan tulang ‘femur’ dalam kajian ini dan boleh digunakan sebagai kaedah klinikal alternatif yang boleh dipercayai untuk menganggarkan kepanjangan besi maxima intramedula tulang ‘femur’.

Kata Kunci:

Kepatahan tulang ‘femur’, Panjang besi intramedula, Panjang tulang ‘fibula’, Panjang tulang ‘femur’

ABSTRACT

Introduction

Diaphyseal femur fractures are a common presentation in orthopaedics and are routinely managed with intramedullary fixation. Appropriate nail length and size is required to be measured preoperatively. Maximum nail length can be estimated by measuring either clinically or radiographically the contralateral femur or by using forearm referencing. However, these methods are inadequate when patients present with bilateral femoral bone fractures with concurrent forearm fractures. The aim of this study is to identify another reliable clinical method in estimating the maximum femoral nail length.

Materials and methods

A total of 140 patients who attended the Orthopaedic clinics and wards at Hospital Universiti Sains Malaysia (HUSM) that met the inclusion and exclusion criteria were chosen using a convenience sampling method and participated in this cross-sectional study. Their estimated maximum femoral nail length (EFNL) and fibula length were measured using a tailor measuring tape on the ipsilateral limb. The EFNL was measured according to the standard AO method while the fibula was measured from the tip of the fibula head to the tip of the lateral malleolus. These data were collected and analyzed using SPSS version 26. Descriptive statistics was used to summarize the socio-demographic characteristics of the subjects. Numerical data were presented as mean (SD) or median (IQR) based on their normality distribution, while categorical data were presented as frequency (percentage).

Results

Of the 140 patients measured, the overall mean EFNL was 37.98cm (± 2.72 cm) while the fibula length was 37.72cm (± 2.61 cm). The Pearson's Correlation analysis showed that the fibula length was highly correlated with the EFNL, and this correlation was not influenced by age, BMI or gender. Interclass correlation analysis (ICC) showed high degree of inter-observer reliability in the both the femur (ICC 0.938 with a 95% confidence interval) and fibula (ICC 0.972 with a 95% confidence interval) measurements. A formula for estimating maximum femoral nail length was derived from the correlation graph.

$$\text{Estimated maximum femoral nail length} = 1 + (0.98 \times \text{fibula length})$$

Conclusion

The fibula length is shown to correlate well with the clinical measurement of EFNL in this study and can be used as a reliable alternative clinical method to estimate the maximum femoral nail length.

Keywords:

Diaphyseal femur fracture, Intramedullary nail length, Fibula length, Estimated Femoral Nail Length

CHAPTER 1: INTRODUCTION

1.1 INTRODUCTION

Diaphyseal femur fractures are a common presentation in the emergency department that result from high energy trauma injuries and are common in road traffic accidents. The worldwide incidence of such fractures range from 1.0-2.9 million per year.(1) These fractures require hospital admissions and operative management. Intramedullary nailing is the current gold standard in treating these fractures.(2) As such, the operation theatre will require to carry a large variety and range of lengths and sizes of these nails in inventory. It is however not practical to assume that all nail lengths are available intraoperatively and thus it is imperative that orthopaedic surgeons assess the size and length of the nails preoperatively. Inadequate nail lengths can result in limb length deformities, a known complication in diaphyseal femur fractures, especially in severely comminuted fractures such as in Winquist type III and IV fractures and commonly end up shortened if inadequately nail lengths are used.(3)

The accepted standard of estimating femoral nail length is by radiographically measuring the intact contralateral femur.(4) There are however clinical methods to estimate the maximum femoral nail length that do not require the use of x-ray radiation as described by Arbeitsgemeinschaft für Osteosynthesefragen (AO) as well as a recently studied alternative method of measuring the forearm length from the tip of the olecranon to the tip of the little finger that are useful in bilateral femoral fractures or in cases where patients are obese and palpation of the greater trochanter (GT) is complicated.(4-7) These clinical methods of estimating maximum femoral nail length can however be inadequate when patients present

with bilateral femoral bone fractures with concurrent bilateral upper limb fractures or are known to have bone or joint deformities of the upper limbs.

Therefore, the aim of this study is to identify another reliable clinical method in estimating maximum femoral nail length when it is not feasible to measure the contralateral femur or use the forearm referencing method, by measuring the fibula length.

1.2 OBJECTIVE

General Objective:

To study the association of clinical measurement of EFNL using standard AO method with fibula length in estimating maximum femoral nail length and the inter observer reliability of each method.

Specific Objectives:

1. To determine the correlation between clinical measurement of EFNL and fibula length.
2. To determine formula to estimate maximum femoral nail length from fibula length.
3. To demonstrate consistency between observers in clinical measurement of EFNL and fibula length.

CHAPTER 2: STUDY PROTOCOL

DISSERTATION PROPOSAL

**TITLE: A Comparison Study between the
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Femoral Nail Length**

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INTRODUCTION

Diaphyseal femur fractures are a common presentation in the emergency department that result from high energy trauma injuries and are common in road traffic accidents. The worldwide incidence of such fractures range from 1.0-2.9 million per year.(1) These fractures require hospital admissions and operative management. Intramedullary nailing is the current gold standard in treating these fractures.(2) As such, the operation theatre will require to carry a large variety and range of lengths and sizes of these nails in inventory. It is however not practical to assume that all nail lengths are available intraoperatively and thus it is imperative that orthopaedic surgeons assess the size and length of the nails preoperatively. Inadequate nail lengths can result in limb length deformities, a known complication in diaphyseal femur fractures, especially in severely comminuted fractures such as in Winquist type III and IV fractures and commonly end up shortened if inadequately nail lengths are used.

The accepted standard of estimating femoral nail length is by radiographically measuring the intact contralateral femur.(4) There are however clinical methods to estimate the maximum femoral nail length that do not require the use of x-ray radiation as described by Arbeitsgemeinschaft für Osteosynthesefragen (AO) as well as a recently studied alternative method of measuring the forearm length from the tip of the olecranon to the tip of the little finger that are useful in bilateral femoral fractures or in cases where patients are obese and palpation of the greater trochanter (GT) is complicated.(4-7) These clinical methods of estimating maximum femoral nail length can however be inadequate when patients present

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Therefore, the aim of this study is to identify another reliable clinical method in estimating maximum femoral nail length when it is not feasible to measure the contralateral femur or use the forearm referencing method, by measuring the fibula length.

LITERATURE REVIEW

The femur is the only bone in the thigh and is the longest, heaviest, and strongest bone in the human body. It functions to support the whole upper body weight sent through the pelvis to both the femoral heads.

The proximal end of the femur forms a spherical head wrapped with cartilage which is attached to the femoral shaft at an angle of 125° via the femoral neck.(8)

Two bony projections arise from the proximal femur where the neck joins the shaft for attachments of muscles. The larger projection that extends superiorly over the lateral and posterior part is the greater trochanter which is the first palpable bony prominence on the proximal lateral surface of the thigh while the medial smaller projection is called the lesser trochanter. The shaft of the femur is angled slightly obliquely towards the medial aspect and has a slight anterior bowing. The distal end of the shaft flares out to form the medial and lateral condyles that join anteriorly to form the trochlear surface and posteriorly by the intercondylar fossa. The condyles are covered distally with cartilage and articulate with the patella and tibia. The adductor tubercle arises at the medial aspect of the medial epicondyle and is bisected by the distal epiphysis of the femur.(8)

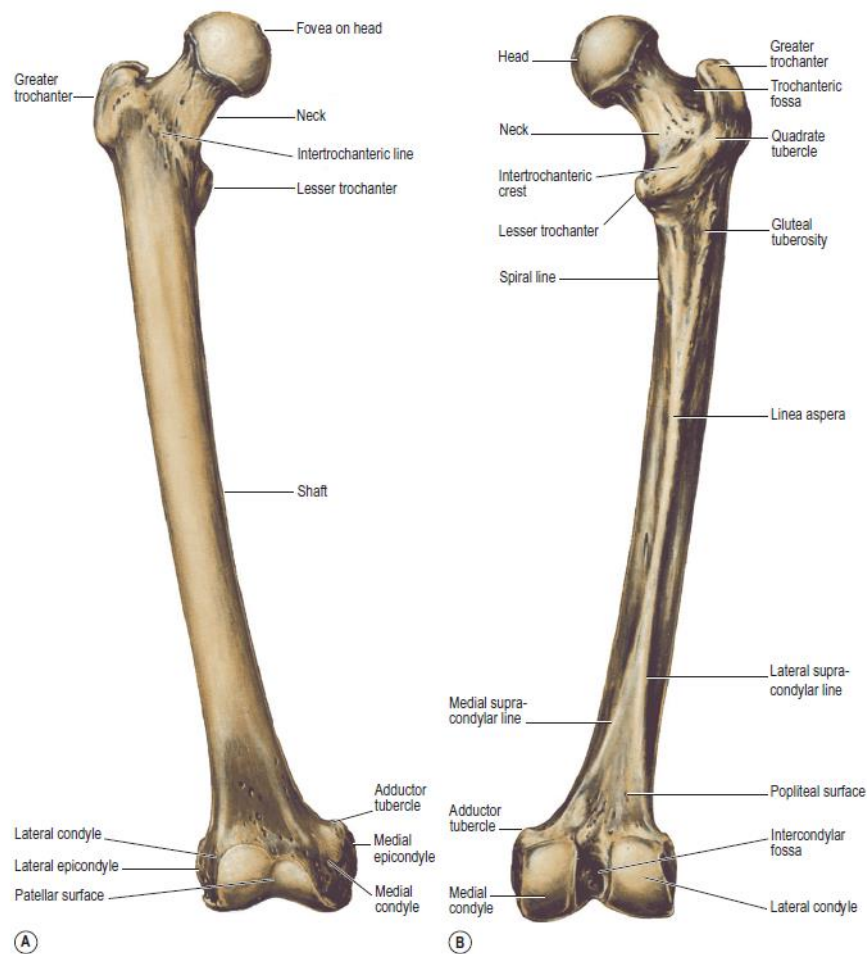


Figure 1 Femur Bone A – anterior view. B – posterior view.(8)

Sinnatamby CS. Last's Anatomy e-Book: Regional and Applied: Elsevier Health Sciences; 2011. p.169

Diaphyseal femoral bone fractures are routinely fixed with an intramedullary nail. The nail is made from titanium and has an anterior bow as well as a medial to lateral angulation to fit the anatomical canal of the femur.(9) It is inserted from the GT and ends at the superior pole of patella and is locked in place with screws in the proximal and distal part of the nail.(9) The femoral length is usually measure radiographically on an intact femur from the tip of the greater trochanter to just above the epiphyseal scar of the distal femur.(10) This represents the adequate longest femur nail length that is required. The gold standard in estimating maximum femoral nail length is by

radiographically measuring the intact contralateral femur.(4) This requires the use of x-ray radiation with accurate magnification as well as an intact non diseased contralateral femur.(5)

There are also routine commonly practiced clinical measurement methods to estimate the maximum femoral nail length. AO has described two clinical measurement methods to estimate the maximum femoral nail length such as by measuring the tip of the GT of the femur to the superior pole of the patella as well as the tip of the GT to the lateral knee joint line minus 2cm.(4)

Alternatives to this method have been recently studied such as using the forearm plus little finger length.(5, 6, 11) This method has been shown to correlate well with the EFNL and can be used as an alternative in estimating maximum femoral nail length.(5, 6, 11)

A study by Karakas and Harma in 2007 showed the femoral medullary length measured radiographically from the fossa piriformis to the intermedullary notch correlated well with radiographically measured fibula length added with the radiographically measured femoral head diameter, $r=0.942$ ($p<0.0001$).⁽¹²⁾ However, clinical measurements of fibula length was not documented in this study.

The fibula is a long bone located at the lateral aspect of the leg slightly posterior to the tibia and just below the knee joint. The fibula head is superficial and the styloid process that projects upwards from the lateral part of the head is easily palpable.(8) The fibula terminates at the ankle as the lateral malleolus. The tibia can also be measured clinically, however unlike the fibula it does not have a styloid process that acts as a single palpable proximal tip, and therefore is measured clinically from the medial knee joint line to the medial malleolus.

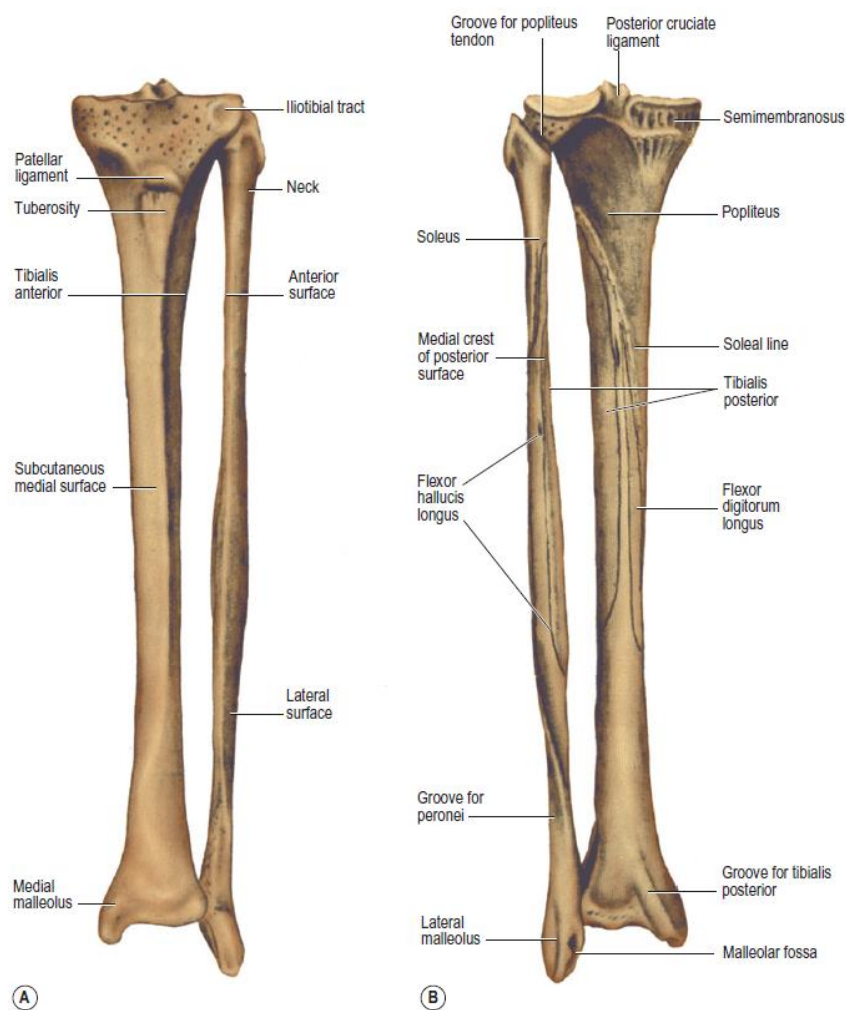


Figure 2 – Left Tibia and Fibula A- Anterior View, B – Posterior View (8)

Sinnatamby CS. Last's Anatomy e-Book: Regional and Applied: Elsevier Health Sciences; 2011. p.172

Gaps in knowledge

- Current alternatives involve measurement of forearm length however it is not possible in patients with bilateral forearm fractures or upper limb deformities.
- There is no current study to estimate maximum femoral nail length by clinically measuring the fibula length.

Problem Statement & Study Rationale

Is there any other clinical method that is both accurate and reliable as an alternative to estimate the maximum femoral nail length in patients with bilateral femur fractures and concurrent bilateral forearm fractures?

Research Question(s)

Is the clinical measurement of fibula length an accurate and reliable alternative method to estimate maximum femoral nail length?

Objective

General:

To study the association of clinical measurement of EFNL using standard AO method with fibula length in estimating maximum femoral nail length and the inter observer reliability of each method.

Specific:

- To determine the correlation between clinical measurement of EFNL and fibula length
- To determine formula to estimate maximum femoral nail length from fibula length
- To demonstrate consistency between observers in measurement of EFNL and fibula length

Justification of Study:

- The current used clinical method of estimating femoral nail length is via the AO method(4) and this however requires an intact contralateral femur. As pointed out by Karakas and Harma, even radiological methods of measuring femoral nail length require an intact contralateral femur and these techniques are inadequate in bilateral comminuted femur fractures.(12)
- The current alternative clinical method for estimating maximum femoral nail length is by the length taken from the tip of the olecranon to the tip of the little finger.(13) This method however has many variables due to the measurement crossing multiple joints and bones, we thus need to keep the joints in proper alignment and without any pathology or fractures. The fibula however is a single superficial long bone with easily palpable prominent proximal and distal ends that terminate at single points.(8) Therefore, it will give a more constant measurement.
- The method we propose will be useful in patients with bilateral comminuted femur fractures with concurrent upper limb fractures, where tip of olecranon to tip of little finger cannot be measured.
- The method we propose requires no used of x-rays and there more there is no unnecessary radiation.
- Can be used in obese patients when palpation of GT may be difficult as the fibula is a superficial bone with easily palpable prominences at its head

and lateral malleolus and the measurement of the fibula does not cross any joints.(8)

- The method we propose does not require palpation of the knee joint line or superior pole of the patella and therefore this method can be used in patients with abnormal riding patella, knee deformities or concurrent fractures of the patella.
- The method we propose does help to protect the patient's modesty by not requiring the patient to expose the upper part of the thigh.

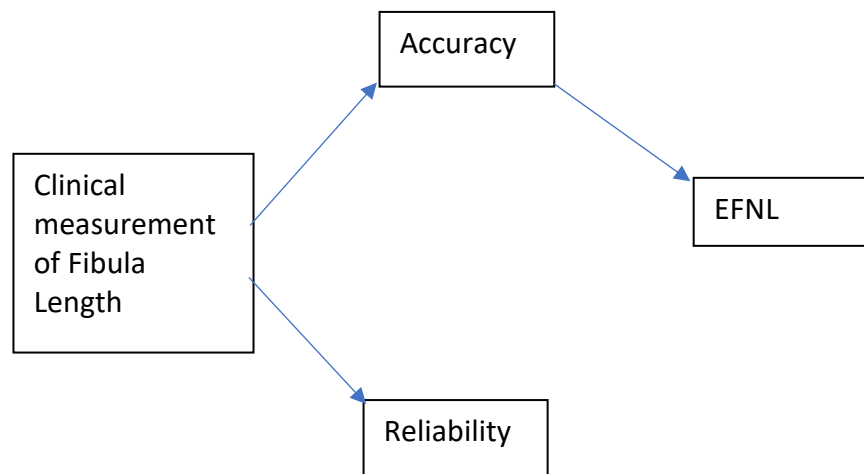
Justification of Methodology:

The fibula has easily palpable bony prominence at each end, that is the fibula head and tip of lateral malleolus. It is a single straight long bone and the measurement does not cross any joints.(8)

The current clinical AO method of measurement of GT to the superior pole of patella correlates well with the EFNL and has been practiced regularly in estimating maximum femoral nail length.(4)

Therefore, it is justifiable to compare the clinical measurement of fibula length with the AO method to prove the correlation between EFNL and fibula length in estimating maximum femoral nail length.

Conceptual Framework



Accuracy by correlating and comparing fibula length to the EFNL.

Reliability of the measurement by testing the inter-observer measurement.

METHODOLOGY

Research design

Cross sectional study

Study area

Patients of Hospital University Sains Malaysia, Kubang Kerian.

Study population

Male and female patients that attended the HUSM orthopaedic clinics and those admitted in orthopaedic wards.

Subject criteria

Inclusion Criteria:

- Patients of HUSM
- Male & Female
- Age 18-60

Exclusion Criteria:

- Any Lower Limb Deformities or Limb Length discrepancy
- Any pathology of bones/joints
- Any history of lower limb fractures
- Any known skeletal diseases

Sample size estimation

Objective 1

Objective: To determine the correlation between EFNL and fibula length.

Method: We applied the Pearson's Correlation Formula using Sample Size Calculator by Arifin, W. N. (2021) to estimate our sample size of the first objective. Details of the formula is listed below:

- Expected correlation (r) of EFNL and fibula length = 0.86 (Naik M.A. *et al* 2013)
- Precision ($\pm$ expected) = 0.05
- Confidence level $100(1 - \alpha) = 95\%$
- Drop-out rate = 10 %
- Number of sample size (n) = 110
- Sample size (with 10% dropout), $ndrop = 123$

Objective 2

Objective: To determine formula of estimation of maximum femoral nail length from fibula length

Method: A formula will be derived from the correlation graph

Objective 3

Objective: To demonstrate consistency between observers in measurement of femur and fibula length

Method: We applied the Intraclass Correlation Coefficient (ICC) - Hypothesis Testing using Sample Size Calculator by Arifin, W. N. (2021) to estimate our sample size. Details of the formula is listed below:

- Minimum acceptable reliability (ICC) (ρ_0) = 0.97 (Naik M.A. *et al* 2013)
- Expected reliability (ICC) (ρ_1) = 0.9
- Significance level (α) = 0.05 Two-tailed
- Power ($1 - \beta$): 80 %
- Number of raters / repetitions per subject (k) = 2
- Expected dropout rate = 10 %
- Sample size, $n = 22$
- Sample size (with 10% dropout), $ndrop = 25$
- Total Sample size, $n = 50$

Final Sample Size

The final total sample size for our study is 140 samples.

Sampling method and subject recruitment

Convenience sampling.

Patients of HUSM who attend the clinical and wards during the time of study and meets inclusion and exclusion criteria.

Research tool

Tailor measuring tape (150cm). Brand: Butterfly

Operational definition

- Estimated Femoral Nail Length (EFNL): (Figure 3)

Tip of Greater Trochanter of Femur to Superior Pole of Patella (AO Method)

Tip of GT identified as the tip of the first most prominent bony landmark at proximal lateral thigh

Superior Pole of patella Identified as the most proximal tip of the patella at the anterior aspect of the knee with knee in full extension

- Fibula Length: (Figure 4)

Tip of Head of Fibula to Tip of Lateral Malleolus

Tip of head of fibula identified as first most prominent bony landmark at lateral aspect of proximal leg

Tip of lateral malleolus identified as the most distal tip of the lateral malleolus at the distal lateral aspect of the leg.

Data collection method

- Patients from the clinic and ward were chosen at random, consent taken and tested if they meet the inclusion and exclusion criteria.
- Two observers took measurements on separate occasions and were isolated from each other.

Observer A: Dr Manharpreet Singh Sandhu

Observer B: Dr Mohd Afiq bin Muhamed Fuad

- Each observer took 3 measurements of the EFNL and 3 measurements of the fibula length. The mean of the EFNL and fibula length are calculated.
- Both observers were blinded to each other's measurements.
- Both observers used the same measuring tape.
- The patients were not informed of the measurements.
- The process took about 15 minutes
- Data was documented in an excel spreadsheet. A research identification number was used to identify each participant and data collected was saved in a password-protected computer and only accessible to the research team members.

Figure 3 – Measurement of EFNL from the GT to the superior pole of the patella to estimate maximum femoral nail length as described by AO.



Figure 4 – Measurement of Fibula Length from the tip of the head of the fibula to the tip of the lateral malleolus



Study flowchart

