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Mechanical Lateral Distal Femoral Angle (MLDFA), Medial Proximal Tibia Angle (MPTA), and Mechanical Axis Deviation (MAD) Value in Young Adults in North Sumatera

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ABSTRACT

Introduction. Reference value to determine the angle of lower extremity is only based on clinical measurement and radiological assessment, which is limited to tibiofemoral angle (TFA). Although this examination can estimate the lower extremity angle, it is not satisfactory for a comprehensive analysis. **Material and Method.** A descriptive study in RSUP Haji Adam Malik Hospital in August - September 2019 to measure mechanical lateral distal femoral angle (MLDFA), medial proximal tibia angle (MPTA), and mechanical axis deviation (MAD). **Results.** Thirty nine subjects were included in this study. The mean age was 26.77 ± 4.65 years old (range: 22 to 39 years); 69,2% were male ($n = 27$) and 30,8% were female ($n = 12$). The average mechanical lateral distal femoral angle (MLDFA) was $87,93^\circ \pm 2,16^\circ$. The average medial proximal tibia angle (MPTA) was $86,28^\circ \pm 2,26^\circ$. The average mechanical axis deviation (MAD) was $1.56 \pm 1,48$ mm. Our results of MLDFA and MPTA measurement, but not in MAD, are consistent with study conducted by Farr, *et al*. **Conclusion.** Our MLDFA, MPTA, but not MAD measurement results are similar to studies involving Caucasian population.

Keywords: Lower extremity angle, MAD, MLDFA, MPTA, TFA

ABSTRAK

Pendahuluan. Nilai acuan sudut pada ekstremitas bawah hanya berdasarkan pemeriksaan klinis dan radiologis, yang terbatas pada sudut tibiofemoral. Pemeriksaan sudut tibiofemoral (STF) tunggal tidak cukup untuk analisis komprehensif ekstremitas bawah. **Bahan dan Cara.** Penelitian deskriptif di RSUP Haji Adam Malik pada bulan Agustus – September 2019 untuk mengukur sudut mekanik lateral distal femur (SMLDF), sudut medial proksimal tibia (SMPT), dan deviasi aksis mekanik (DAM). **Hasil.** Sejumlah 39 subjek diteliti. Usia rata-rata $26,77 \pm 4,65$ tahun (22 - 39 tahun); 69,2% pria ($n = 27$) dan 30,8% wanita ($n = 12$). Nilai rata-rata sudut mekanik lateral distal femur (SMLDF) adalah $87,93^\circ \pm 2,16^\circ$. Nilai rata-rata sudut medial proksimal tibia (SMPT) adalah $86,28^\circ \pm 2,26^\circ$. Nilai rata-rata deviasi aksis mekanik (DAM) adalah $1.56 \pm 1,48$ mm. Pada penelitian ini, hasil pengukuran SMLDF dan SMPT sesuai hasil penelitian Farr, *et al*, tetapi hasil pengukuran DAM tidak sesuai. **Simpulan.** Nilai SMLDF dan SMPT pada penelitian ini tidak berbeda dengan penelitian pada populasi Kaukasia. **Iman Dwi Winanto, Yoyos Dias Ismiarto.** Nilai Sudut Mekanik Lateral Distal Femur (SMLDF), Sudut Medial Proksimal Tibia (SMPT), dan Deviasi Aksis Mekanik (DAM) pada Dewasa Muda di Sumatera Utara.

Kata kunci: Sudut ekstremitas bawah, STF, SMLDF, SMPT, DAM.

Introduction

Reference value to determine the angle of the lower extremity is only based on clinical measurement and radiological assessment, which is limited to tibiofemoral angle (TFA). Although this examination could estimate the lower extremity angle, assessment of TFA is not enough to get a comprehensive analysis for lower extremity.¹ Measurement of TFA in growing children could be problematic

due to varus alignment of the proximal and diaphyseal part of the femoral bone, also because of the torsion from the tibial bone.²

Many methods have been used to examine the TFA, but none have shown significant results, both for men and women. Salenius and Vanka, in 1975, identified the TFA using radiological modality and found that both men and women had 5 to 6 degrees

valgus alignment. Despite the result, this study is costly and carries risk of radiation exposure; so clinical assessment should be considered.³ Radiological examination from anteroposterior (AP) view in erect position and anteriorly located patella remain to be the modality to examine the lower extremity angle, joint orientation angle, and limb-length discrepancies.^{4,5}

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In 1993, Heath and Stahel reported 5.8 degree valgus TFA with radiological examination in American aged 10 to 12 years old,¹ while Cheng,⁶ who examined the TFA clinically, concluded 1 to 9 valgus degrees in China population both in men and women. These findings may imply that TFA are influenced by race.⁷

Normal characteristics of joints of the lower extremity has been a focus in several studies.⁸⁻¹³ Two considerations in evaluating frontal plane of the lower extremity are joint congruency and joint orientation.^{14,15} Alignment refers to collinearity of the hip, knee, and ankle.¹⁶ Paley *et al.* stated that if ML DFA is outside the normal value (85°-90°), femoral bone has the biggest contribution in forming the mechanical axis deviation (MAD), but if MPTA value is abnormal (85°-90°), tibial bone gives the biggest contribution for the MAD.⁴

The aim of this study is to obtain normal value of the frontal plane alignment and joint orientation angles of the lower extremity based on scannogram radiological examination in young adults in North Sumatera.

Materials and Methods

This is a descriptive study to determine the normal value of mechanical lateral distal femoral angle (ML DFA), medial proximal tibia angle (MPTA) and mechanical axis deviation (MAD) in North Sumatera population.

Sample selection was based on the age of 18-35 years, normal BMI, and willingness to participate. This study was conducted in Haji Adam Malik Central General Hospital (RSUP H Adam Malik) during August 2019 until September 2019. Patient data were obtained from scannogram radiological examination and measured the Mechanical Lateral Distal Femoral Angle (ML DFA) which is the lateral angle formed between the mechanical axis line of the femur and the knee joint line of the

femur in the frontal plane, the Medial Proximal Tibia Angle (MPTA) - the medial angle formed between the tibial knee joint line and the anatomical axis of the tibia, and Mechanical Axis Deviation (MAD) - the perpendicular distance from the mechanical axis line to the center of the knee joint line using a long ruler.

This study used interval/ratio scale using this formula¹⁷:

$$\text{sample size } (n) = \frac{(z_{1-\alpha/2})^2 \sigma^2}{d^2}$$

$$(n) = \frac{1,96^2 \cdot 3^2}{1^2}$$

$$(n) = 34,57$$

n = Desired numbers of samples
 $z_{1-\alpha/2}$ = standardized value for the corresponding level of confidence. (at 95% CI, it is 1.96 and at 99% CI or 1% type I error it is 2.58)
 d = margin of error or rate of precision
 σ = SD which is based on previous study or pilot study.

The minimal sample size is 34,57 samples. Samples were taken consecutively until minimal amount of samples was achieved. The exclusion criteria in the study were patients with history of lower limb congenital anomaly and patients with history of lower extremity trauma.

Results

Thirty nine subjects were included in this study. The mean age was 26.774,65 years old (range: 22 to 39 years). Most respondents were male (27 subjects, 69,2%) only 12 subjects were female (30,8%). Mean BMI was $23.29 \pm 3,05 \text{ kg/m}^2$ (range: 18.8 to 29.4 kg/m^2).

Table 1. Sample characteristic distribution

| | BMI | ML DFA | MPTA | MAD |
|---------|--------------|--------------|--------------|-------------|
| Mean | 23.29 ± 3,05 | 87,93 ± 2,16 | 86,28 ± 2,26 | 1.56 ± 1.48 |
| Median | 23,29 | 88 | 86 | 1 |
| Minimum | 18,8 | 84 | 82 | 0 |
| Maximum | 29,4 | 94 | 91 | 5,0 |

BMI: Body Mass Index, ML DFA: Mechanical Lateral Distal Femoral Angle, MPTA: Medial Proximal Tibia Angle, MAD: Mechanical Axis Deviation

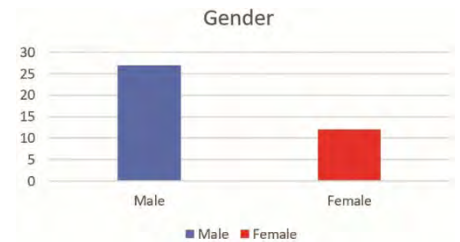
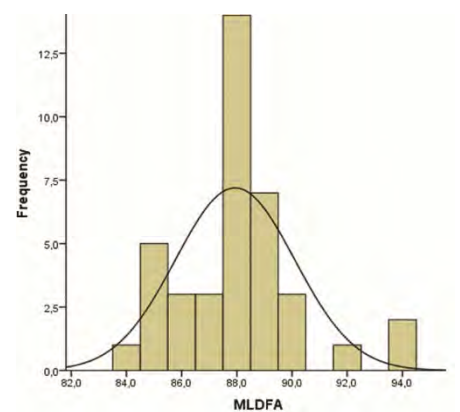


Figure 1. Gender distribution

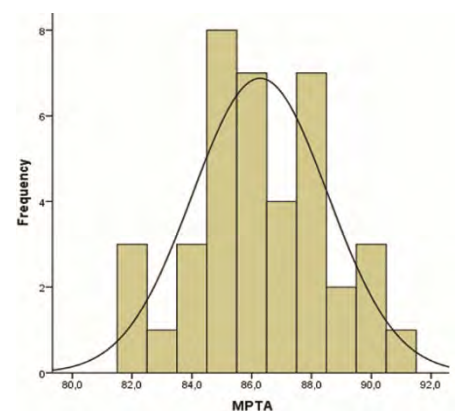
The average mechanical lateral distal femoral angle (ML DFA) was $87,93^\circ \pm 2,16$. The minimum and maximum value were 84° and 94° respectively.



Note: Mean=87,94 ; Std. Dev.=2,162 ; N=39

Figure 2. ML DFA distribution in study

The average medial proximal tibia angle (MPTA) was $86,28^\circ \pm 2,26$. The minimum value was 82° , while the maximum value was 91° .



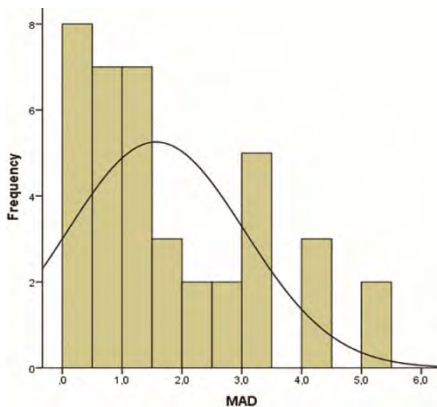
Note: Mean=86,28 ; Std. Dev.=2,262 ; N=39

Figure 3. MPTA distribution in the study

The average mechanical axis deviation (MAD) was $1,56 \pm 1,48$ mm. The minimum and maximum value were 0 mm and 5 mm respectively.



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Note: Mean=1,57 ; Std. Dev.=1,48 ; N=39

Figure 4. MAD distribution in the study

Discussion

The mechanical axis, visualized by a vertical line drawn from the center of the femoral head to the center of the ankle joint, normally passes through the midpoint of the knee joint (eminentiintercondylaris) or slightly medial (8 ± 7 mm) to it. Two considerations in evaluating the frontal plane mechanical axis of the lower extremity are joint alignment and joint orientation. The normal alignment of the hip, knee, and ankle joint centers is colinear.¹⁴

This neutral mechanical axis alignment ensures equal weight transmission through

the medial and lateral compartments of the knee. If the mechanical axis passes through the medial or lateral side of the knee, there will be corresponding increased weight transmitted across the medial or lateral compartment of the knee. These conditions are clinically and radiologically expressed as varus or valgus knee. During normal locomotion, there will be adduction movement at the knee joint. Hence the medial compartment of the knee is overloaded by 50% compared to the lateral compartment.¹⁸

MAD is the distance between the mechanical axis line and the center of the knee in the frontal plane. A lateralized MAD, reflected by an increase of the distance between the mechanical axis and knee joint center, leads to a shift of the mechanical load to the lateral knee compartment.¹⁹ Mechanical distal lateral femoral mechanical angle (mLDFA) is a lateral angle formed between the mechanical axes of the femur bone line and the knee joint line from the femur in the frontal plane. MPTA is measured using simple methods from the knee radiographs, with the normal value of 87° (range 85° - 90°). This angle can represent the correction angle for use in the osteotomy and is usually seen during the operation under fluoroscopic control. Importantly, the MPTA

can be used to detect the correction angle change and recurrent varus deformity during the follow up period.^{20,21}

This study found mean MLDFA from 39 patients was $87,96^\circ \pm 2,16^\circ$; mean MPTA was $86,28^\circ \pm 2,26^\circ$ and mean MAD was $1.56 \text{ mm} \pm 1,48 \text{ mm}$. A study by Farr et al in Caucasian population found that the mean MLDFA was $84,9^\circ \pm 2,9^\circ$; MPTA $90,6^\circ \pm 2,1^\circ$ and MAD $12,9 \text{ mm} \pm 7,6 \text{ mm}$. Paley et al. also suggest normal ranges is 85° - 90° for MLDFA and MPTA and $8 \pm 7 \text{ mm}$ for MAD. They stated that if MLDFA is outside the normal level (85° - 90°), femoral bone has the biggest contribution in forming the mechanical axis deviation (MAD), but if MPTA value is abnormal (85° - 90°), tibial bone gives the biggest contribution for the MAD.⁴ Our result of MLDFA and MPTA measurement but not MAD (which is far above this study value) was consistent with the result of Farr et al study.¹⁹

Conclusion

MLDFA and MPTA values in this study were consistent with other studies on Caucasian race. Further studies needed for determine internationally accepted reference MAD value for clinical use.

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