SMJ Singapore Medical Journal

Change in angle of depressed medial tibial plateau following extra-articular mechanical realignment surgery in children with Blount's disease who presented late for treatment

Zi Hao Phang[1], MBBS(Hons), Mohammed Albaker[1], MMed, Roshan Gunalan[1], MMed, Adrian Yen Xian Lee[1], MBBS, Aik Saw[1], MMed

[1]Department of Orthopaedic Surgery (NOCERAL), University Malaya Medical Centre, Kuala Lumpur, Malaysia

Correspondence: Dr Zi Hao Phang, Orthopaedic Registrar, Department of Orthopaedic Surgery (NOCERAL), University Malaya Medical Centre, 59100 Kuala Lumpur, Malaysia. phangzh@ummc.edu.my

---

Singapore Med J 2021, 1–13

https://doi.org/10.11622/smedj.2021189

Published ahead of print: 8 November 2021

ABSTRACT

Introduction: The aim of this study was to determine whether any change in degree of medial tibia plateau depression after extra-articular mechanical realignment surgery was observed in children with Blount's disease who presented late for treatment in their adolescent and young adulthood.

Methods: We retrospectively reviewed the radiographic parameters of 22 patients (32 lower limbs) with Blount's disease who underwent gradual correction of deformity surgery using ring external fixator without surgical elevation of the depressed medial tibial plateau at a mean age of 15 (10–37) years. Preoperative and postoperative angles of depressed medial tibia plateau (ADMTP) of the same patient were compared for any significant change. Normally distributed data were analysed using Student's *t*-test when comparing two groups or one-way ANOVA when comparing more than two groups. Skewed data were analysed using Mann-Whitney test.

Results: After extra-articular mechanical alignment surgery, statistically significant improvements in medial tibial plateau depression were seen in the Infantile ($p = 0.03$) and Juvenile ($p = 0.04$) Blount's subgroups. Change of ADMTP was greater in patients who were operated on at age < 17 years, before skeletal maturity ($p = 0.001$). The improvement was likely due to ossification of unossified cartilage at the posteromedial proximal tibia and remodelling potential of proximal tibia physis after mechanical realignment.

Conclusion: Improvement of medial tibia plateau depression is possible after mechanical realignment without surgical hemiplateau elevation in cases of Infantile and Juvenile Blount's disease that present late for treatment, especially when the operation is performed before age 17 years old.

Keywords: Blount's disease, deformity, genu varum, orthopaedics, paediatrics

INTRODUCTION

In 1937, Walter Putnam Blount reported progressive tibia vara in young children and the condition was subsequently called Blount's disease.(1) Langenskiold classified Blount's disease into six stages based on radiological appearance of the epiphysis and metaphysis.(2-4) He also grouped them into two distinct entities based on time of onset of the deformity; children with early onset Blount disease would have an age of onset 4 years old or less, where the medial tibial plateau progressively worsens as the child grows older. Children with late onset Blount disease would have an age of onset older than 4 years old and generally have less severe deformity of the medial plateau.(2-4) Others further classified this condition into Infantile Blount (4 years or less), Juvenile Blount (5 to 10 years), and Adolescent Blount (11 years or more).(5)

Non operative treatments such as use of braces and orthosis had been described for early stage infantile Blount disease in children up to 3 years old.(6) If deformity does not resolve, the definitive treatment is surgery. Growth modulation is an option for mild deformity in children who have not reached skeletal maturity.(7) For severe deformity, valgus osteotomy of proximal tibia with either acute or gradual correction using internal or external fixator may be indicated.(6) For deformities associated with significant depression of the posteromedial tibial plateau, the current trend of treatment requires medial hemiplateau elevation using intraarticular osteotomies to complement the procedure to correct mechanical alignment.(8-10) Some studies proposed the indication for medial hemiplateau elevation if the angle of depressed medial tibia plateau (ADMTP) is more than 30°.(10-13) However, there are neither recent studies reporting on the natural history of the proximal tibia development nor studies validating the actual indication of medial tibia plateau elevation. Proponents of medial tibia plateau elevation surgery claim this surgery is aimed to prevent the development of early osteoarthritis of the knee joint.(6,10,13) Nevertheless, medial tibia plateau elevation surgery involves intra-articular osteotomy which could create an additional insult to the developing proximal tibia physis in a child. The exact timing to do this surgery is controversial. There were many studies describing the technique of medial plateau elevation.(8,11) However, there were also no landmark studies in the literature providing evidence that this surgery will reduce the incidence of early osteoarthritis in Blount's disease.

In our setting, there were many patients with Blount's disease who presented late for treatment in their adolescents and young adults. We did not practise medial tibia plateau elevation surgery for these cases because of concern of additional damage to the medial tibia physis and the knee joint from this invasive procedure. These children present with severe deformity of the knee joint at presentation. Our approach was extra-articular realignment of the mechanical axis using ring external fixators and monitor the medial plateau depression until patients reached skeletal maturity.

The research question was whether the severity of medial tibial plateau depression would change after extra-articular mechanical realignment surgery. The null hypothesis was there would be no change in angle of depressed medial tibial plateau after extra-articular mechanical realignment surgery.

METHODS

We conducted a retrospective study on patients with Blount's disease who presented late for treatment in their adolescents or young adulthood. After we obtained the approval of the Institution Research Ethics Committee, we searched the hospital database for patients diagnosed with Blount's disease from 2002 to 2017. All patients more than 10 years old who had undergone extra-articular deformity correction for Blount's disease were included. Those who had genu varum secondary to other aetiologies such as trauma, metabolic diseases or skeletal dysplasia were excluded. In order to reduce the risk of soft tissue complications and further injury to the intra-articular structures, all patients were treated with distraction osteogenesis through a single level corticotomy at the level just below the tibia tubercle, using ring external fixator, without surgical elevation of the depressed medial tibia plateau. Description of the procedure and type of external fixator used has been reported in our previous publication.(14)

Clinical information including patient demographics, treatment details and radiographs of patients were collected and analysed. We contacted a few patients for missing information. Patients who had loss to follow up during treatment were excluded. Lower limb mechanical axis alignment and proximal tibia deformity were evaluated using a standing lower limb plain radiograph. We compared the pre-operative radiograph with the post-operative radiograph taken on the last follow up after frame removal. All radiographic measurements were made by a single investigator (ZHP) who had not been involved in treating the patients using the digital imaging software system (PACS, GE Healthcare, Chicago, Illinois, USA). Standard radiological parameters including lateral distal femur angle (LDFA), medial proximal tibia angle (MPTA), lateral distal tibia angle (LDTA), joint line convergence angle (JLCA) and mechanical axis deviation (MAD) were measured. In addition, we also measured parameters described by Hefny including tibiofemoral angle (TFA), femoral condyle tibial shaft angle (FCTSA) and ADMTP.(8) To further analyse the changes in the medial tibia plateau, we measured 3 arbitrary additional angles which are first, the angle subtended by a line parallel to the lateral tibial plateau and a line connecting the most lateral and most medial point of the proximal tibia joint line (alpha angle); second, the angle subtended by a line perpendicular to the lateral tibia plateau and the mechanical axis line of the tibia connecting the midpoint of the knee joint to the midpoint of the ankle joint (beta angle); and third, the angle subtended by the mechanical axis line of the tibia and a line connecting the most lateral and most medial point of the proximal tibia joint line (gamma angle) (*Fig. 1*). The normal alpha angle is 0° in which the lateral tibial plateau is at the same height with the medial tibia plateau. The normal beta angle is 0°, in which the line perpendicular to the lateral tibial plateau is parallel to the tibia mechanical axis line connecting the centre of the knee and ankle joints. The normal gamma angle is 90°, in which the tibia mechanical axis line is perpendicular to both the medial and lateral tibial plateau.

We further subdivided the patients into 3 groups based on the age of onset for analysis of medial tibia plateau depression: Infantile Blount's (≤ 4 years old), Juvenile Blount's (5-10 years old), and Adolescent Blount's (≥ 11 years old), noting that Infantile and Adolescent group patients behave differently as described by Langenskiold.(2)

Normality test performed on all collected parameters using Shapiro Wilk test. Parametric data that were normally distributed were analysed using Student T test when comparing two groups or one-way ANOVA when comparing more than two groups. Meanwhile parametric data that were not normally distributed were analysed using Mann Whitney test. P value of less than 0.05 was significant to reject the null hypothesis of no change in ADMTP after extra-articular mechanical realignment surgery.

RESULTS

There were 71 patients with pathological genu varum treated during the study period. 24 patients were diagnosed as Blount's disease and were operated at an age more than 10 years old. 2 patients were excluded because loss to follow up during treatment and were uncontactable. Eventually, the study sample consists of 22 patients and 32 lower limbs. There were 12 male and 10 female patients. 10 of them had bilateral knee surgery and 12 had unilateral surgery. The average age of onset of the deformity was 8 years old (1-20 years old). There were 6 patients (10 limbs) with Infantile Blount's, 10 patients (14 limbs) with Juvenile Blount's and 6 patients (8 limbs) with Adolescent Blount's. The mean age of corrective surgery was 15 years old (10-37 years old) and the mean duration on external fixator frame was 296 days. Meanwhile, the mean duration of follow up was around 3 years (1195 days).

Surgery managed to correct the MAD from 94 mm medial to the centre of the knee joint to 9 mm medial to the centre of the knee joint. There was significant improvement in MPTA from 44° to 81° following correction of proximal tibia varus angulation ($p<0.05$). The median values of these two parameters remained within the normal limits throughout the period of treatment and follow up. For other coronal plane alignments that involved the proximal tibia, we noted statistically significant improvement after surgery ($p<0.05$); TFA improved from 31° varus to 2° valgus, FCTSA improved from 53° varus to 86° varus, and joint line convergence angle (JLCA) also improved from 7° to 2° (*Table I*). We did not notice any obvious difference between the preoperative and postoperative LDFA (88° vs 87°) and LDTA (88° and 90°) (*Table I*).

In addition, parameters of medial tibia plateau depression also improved during follow up. We noted a statistically significant improvement in ADMTP in Infantile Blount's from 43° to 32° ($p=0.03$) and Juvenile Blount's from 35° to 24° ($p=0.04$). For Adolescent Blount's, ADMTP changes from 33° to 23° but not achieving statistical significance ($p=0.09$). Arbitrary additional angles created to analyse medial tibial depression also showed reduced depression after surgery, consistent with the changes of ADMTP mentioned above (*Table II*).

We subsequently conducted further analysis to study 4 possible factors that could have influenced the change in ADMTP, and these factors included age of surgery, presence of proximal tibia physis, age of onset of Blount's disease and severity of varus angulation (MAD). When we compared mean changes in ADMTP based on age of surgery, we divided into 2 groups which were 17 years old or more (after skeletal maturity) and less than 17 years old (before skeletal maturity). We noticed a significant difference in change of ADMTP in which children evaluated after skeletal maturity had little change in ADMTP compared to children evaluated before skeletal maturity (-1.2° vs -12.5°, p<0.05). Subsequently, we compared the change in ADMTP between children with radiological evidence of proximal tibia physis and those whom physis cannot be visualized. Presence of lateral proximal tibia physis was chosen to evaluate remodelling potential because in many patients medial proximal physis were affected by medial plateau depression and hence difficult to visualise. The mean value of change was -13.6° for those with open physis compared to -6.5° for those without physis which showed a trend of more change in ADMTP with open physis, but the change was not significant (p=0.14). (*Table III*).

For age of onset, we divided the patients into three age groups: Infantile Blount's, Juvenile Blount's and Adolescent Blount's. Mean changes of ADMTP before surgery and during follow up were -11.1°, -10.4° and -10.8° respectively and not statistically significant (ANOVA F=0.01; p=0.99). For severity of varus angulation, we divided the patients into four groups based on Mechanical Axis Deviation (MAD): 0-5 cm, 5-10 cm, 10-15 cm and 15-20 cm medial. The change in ADMTP for these four groups of patients were -8.5°, -6.6°, -19.1° and -9.3° and not statistically significant (ANOVA F=1.56; p=0.22).

DISCUSSION

This study has a sample size of 22 patients with Blount's disease with the average age of 15 years old in which patients had undergone extra-articular mechanical realignment surgery using ring external fixators. As expected, postoperative mechanical alignment managed to be corrected well using this method. Our clinical findings were similar with many other studies using gradual correction and ring external fixators to correct severe deformity of Blount's disease in patients who presented late for treatment.[9,12,14]

Our patients with Infantile Blount's had a pre-operative mean ADMTP 43°, meanwhile those with Juvenile Blount's and Adolescent Blount's had a pre-operative mean ADMTP 35°

and 33° respectively. Patients with Infantile Blount's had a trend towards greater pre-operative medial tibia plateau depression compared to those with Juvenile and Adolescent Blount's but did not achieve statistical significance (p=0.06). This finding may be consistent with Langenskiold description of early onset Blount's had more severe medial plateau depression than late onset cases.[2] Fitoussi et al looked at 6 infantile Blount's patients who presented late for treatment at the average age of 11 years old reported pre-operative ADMTP of 42°.[11] Hefny looked at 5 infantile Blount's patients who also presented late for treatment with the average age of 11.6 years old reported pre-operative ADMTP of 53°.[8] Our study had 6 patients (10 limbs) with Infantile Blount's who presented late for treatment with an average age 13.6 years old reported pre-operative ADMTP of 43°. Our study had a higher mean age but no worsening of medial tibia plateau depression. Although Langenskiold classification described progressively worsening of medial tibia plateau depression up to the age of 10 years old, but the progression of medial tibia plateau depression for patients with Blount's disease who seek treatment late in their adolescent age is still not well elucidated in literature.

We did not perform surgical elevation of medial tibia plateau in all patients and therefore we did not expect any significant improvement in medial tibia plateau depression. However, our study showed an unexpected improvement in ADMTP after extra-articular mechanical realignment surgery. The improvement in ADMTP were statistically significant in Infantile Blount's and Juvenile Blount's subgroups (p<0.05) but not statistically significant in Adolescent Blount's subgroup (p=0.09). These findings were significant to reject the null hypothesis of no change in angle of depressed medial tibia plateau after extraarticular mechanical realignment surgery.

Potential for improvement in ADMTP seemed to vary according to age of surgery of the patients. Patients who had attained skeletal maturity (age ≥17 years old) had little change in ADMTP compared to children who did not reach skeletal maturity (age <17 years old). In addition, there was a trend towards more improvement in ADMTP in children with open proximal tibia physis compared to those without physis, although the difference was not statistically significant (p=0.14). Our results indicated during the growth spurt in adolescents, there is more potential for radiological reduction in ADMTP. One potential reason these findings is the space created by the depressed medial tibial plateau might not actually be a true defect. Our findings support previous MRI studies which have shown this space might be occupied by unossified cartilage.[15-17] Our study showed a clinical observation of the ability of this unossified cartilage over the posteromedial tibia plateau to ossify over time, especially after mechanical realignment.

Surgery performed for our patients was aimed at correcting alignment to obtain normal mechanical axis and offload pressure to the medial knee joint. Theoretically, by offloading the pressure to the medial knee joint, it results in growth and remodelling of the medial tibia physis as described by Delpech’s Law, which resulted in ossification of the unossified cartilage.[17] We postulated that many of our patients were operated near skeletal maturity and hence after surgery, the cartilage might well be ossified resulting in an apparent lower ADMTP on radiograph. The findings of our study indicate the unpredictable remodelling potential of the proximal tibia physis in a skeletally immature children with Blount’s disease in their adolescent age. The most appropriate timing to perform hemiplateau elevation is still subjected to debate given the notoriously unpredictable remodelling potential of proximal tibia physis especially in children with Infantile and Juvenile Blount’s.

Our study included patients with Blount’s disease who presented late for treatment in their adolescence and young adulthood, which is not commonly covered in previous literature. It is difficult to get a big sample size from a single institution. Another limitation of this study is the potential recall bias on age of onset of deformity. In addition, many lateral radiographs of the knee especially those taken before 2010 were not aligned to the proximal tibia and this precluded measurement and evaluation of sagittal plane deformity. We also did not have an MRI, arthrogram or ultrasonography imaging to provide more information on the non-bony structures over the knee joint.

In conclusion, this study on 22 patients (32 affected limbs) with Blount's disease presented late for treatment who had extra-articular correction of deformity to realign mechanical axis, showed a significant improvement in ADMTP after mechanical realignment in the Infantile and Juvenile subgroups. This change reflects the remodelling potential of the medial tibia physis after mechanical realignment for children with Infantile and Juvenile Blount's disease when they are approaching adolescent age. The remodelling potential is greater in children operated on at age less than 17 years old before they reached skeletal maturity.

REFERENCES

1. Blount WP. Tibia vara, osteochondrosis deformans tibiae. Curr Prac Orthop Surg 1966; 3:141-56.
2. Langenskioeld A, Riska EB. Tibia vara (osteochondrosis deformans tibiae): a survey of seventy-one cases. J Bone Joint Surg Am 1964; 46:1405-20.
3. Langenskiöld A. Tibia vara: osteochondrosis deformans tibiae. Blount's disease. Clin Orthop Relat Res 1981; (158):77-82.
4. Langenskiöld A. Tibia vara. A critical review. Clin Orthop Relat Res 1989; (246):195-207.
5. Gordon JE, Heidenreich FP, Carpenter CJ, Kelly-Hahn J, Schoenecker PL. Comprehensive treatment of late-onset tibia vara. J Bone Joint Surg Am 2005; 87:1561-70.
6. Sabharwal S. Blount disease. J Bone Joint Surg Am 2009; 91:1758-76.
7. Abdelgawad AA. Combined distal tibial rotational osteotomy and proximal growth plate modulation for treatment of infantile Blount's disease. World J Orthop 2013; 4:90-3.

8. Hefny H, Shalaby H, El-Kawy S, Thakeb M, Elmoatasem E. A new double elevating osteotomy in management of severe neglected infantile tibia vara using the Ilizarov technique. J Pediatr Orthop 2006; 26:233-7.

9. McCarthy JJ, MacIntyre NR 3rd, Hooks B, Davidson RS. Double osteotomy for the treatment of severe Blount disease. J Pediatr Orthop 2009; 29:115-9.

10. Schoenecker PL, Johnston R, Rich MM, Capelli AM. Elevation of the medical plateau of the tibia in the treatment of Blount disease. J Bone Joint Surg Am 1992; 74:351-8.

11. Fitoussi F, Ilharreborde B, Lefevre Y, et al. Fixator-assisted medial tibial plateau elevation to treat severe Blount's disease: outcomes at maturity. Orthop Traumatol Surg Res 2011; 97:172-8.

12. Jones S, Hosalkar HS, Hill RA, Hartley J. Relapsed infantile Blount's disease treated by hemiplateau elevation using the Ilizarov frame. J Bone Joint Surg Br 2003; 85:565-71.

13. Birch JG. Controversies in Blount's disease. In: Pediatric Lower Limb Deformities: Principles and Techniques of Management. Springer, 2016: 503-16.

14. Saw A, Phang ZH, Alrasheed MK, et al. Gradual correction of proximal tibia deformity for Blount disease in adolescent and young adults. J Orthop Surg (Hong Kong) 2019; 27:2309499019873987.

15. Mukai S, Suzuki S, Seto Y, Kashiwagi N, Hwang ES. Early characteristic findings in bowleg deformities: evaluation using magnetic resonance imaging. J Pediatr Orthop 2000; 20:611-5.

16. Sabharwal S, Wenokor C, Mehta A, Zhao C. Intra-articular morphology of the knee joint in children with Blount disease: a case-control study using MRI. J Bone Joint Surg Am 2012; 94:883-90.

17. Stanitski DF, Stanitski CL, Trumble S. Depression of the medial tibial plateau in early-onset Blount disease: myth or reality? J Pediatr Orthop 1999; 19:265-9.

Table I: Frontal Alignment Measurement of Gradual Correction of Deformity

	Normal value	Pre-operative	Post-operative	P value
LDFA	85° to 90°	88° (6°)	87° (6.5°)	0.13
LDTA	85° to 93°	88° (6.5°)	90° (3°)	0.47
MPTA	85° to 90°	44° (7° to 94°)	81° (50° to 111°)	**<0.001**
MAD (mm)*	3 to 17	94 (14 to 214)	9 (−65 to 112)	**<0.001**
TFA [ˠ]	−5°	31° (10° to 57°)	−2° (−38° to 27°)	**<0.001**
FCTSA	90°	53° (23° to 77°)	86° (60° to 120°)	**<0.001**
JLCA	0° to 2°	7° (10.5°)	2° (3°)	**<0.001**

TFA= tibiofemoral angle, FCTSA= femoral condyle tibial shaft angle, JLCA= joint line convergence angle, MAD= mechanical axis deviation, LDFA= lateral distal femoral angle, LDTA= lateral distal tibia angle. MPTA= medial proximal tibia angle

Normally distributed data presented as Mean (Range), skewed data presented with Median (IQR).

* positive MAD values indicate MAD is medial to knee joint. ˠ positive TFA indicates varus alignment, negative TFA indicates valgus alignment.

Table II: Medial Tibial Plateau Depression

Blount's	Angles	Pre operative	Post operative	P value
Infantile (n=10)	ADMTP	43° (25° to 60°)	32° (2° to 79°)	**0.03**
	α	19° (10° to 31°)	6° (1° to 11°)	**<0.001**
	β	18° (8° to 36°)	4° (−8° to 13°)	**0.002**
	γ	55° (46° to 67°)	82° (71° to 98°)	**<0.001**
Juvenile (n=14)	ADMTP	35° (20° to 48°)	24° (1° to 48°)	**0.04**
	α	15° (4° to 30°)	8° (1° to 17°)	**0.02**
	β	23° (10° to 56°)	−0.1° (−17° to 13°)	**<0.001**
	γ	58° (24° to 77°)	89° (77° to 105°)	**<0.001**
Adolescent (n=8)	ADMTP	33° (10° to 56°)	23° (4° to 32°)	0.09
	A	16° (8° to 25°)	7° (1° to 11°)	**0.003**
	B	14° (5° to 20°)	−1° (−13° to 6°)	**<0.001**
	Γ	64° (56° to 77°)	91° (83° to 102°)	**<0.001**

Angles Mean (Range). ADMTP= angle of depressed medial tibia plateau, α β γ angles shown in Figure 1. Negative β angle indicates valgus alignment.

Table III: Comparison between Mean Changes of ADMTP based on Various Factors.

Groups	n	Total Change in ADMTP Mean (Range)	P value
a) Age of Onset (year old)			0.99
1-4	10	−11.1° (−37° to 19°)	
5-10	14	−10.4° (−29° to 3°)	
>11	8	−10.8° (−34° to 0°)	
ANOVA		F=0.01	
b) MAD (medial)			
0-5 cm	8	−8.5° (−29° to 0°)	
5-10 cm	10	−6.6° (−27° to 19°)	
10-15 cm	8	−19.1° (−37° to 3°)	
15-20 cm	6	−9.3° (−24° to 3°)	
ANOVA		F=1.56	0.22
c) Age of Surgery (year old)			
<17	27	−12.5° (−37° to 19°)	
≥17	5	−1.2° (−6° to 3°)	
T-test			**<0.05**
d) Physis			
Presence of physis	19	−13.6° (−37° to 19°)	
Absence of physis	10	−6.5° (−34° to 3°)	
T-test			0.14

ADMTP= angle of depressed medial tibia plateau, MAD= mechanical axis deviation, ANOVA= analysis of variance test for parametric data using F statistics.

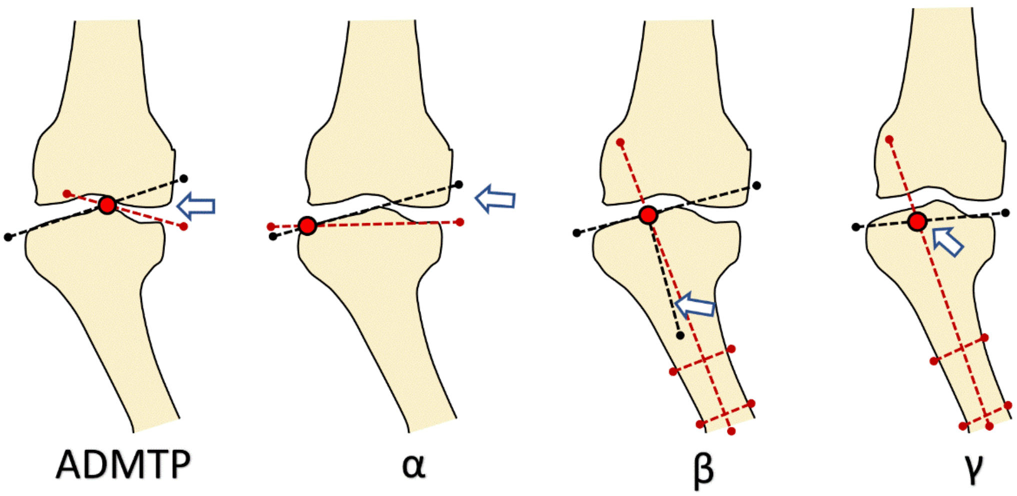

Figure 1 : Illustration showed various measurements used to evaluate medial tibia plateau depression including angle of medial tibia plateau depression (ADMTP), α angle, β angle and γ angle.

Figure 1