Indonesian Journal on Health Science and Medicine
Vol. 1 No. 2 (2024): October
ISSN 3063-8186. Published by Universitas Muhamamdiyah Sidoarjo

https://doi.org/10.21070/ijhsm.v1i2.27

Outcomes of Dome-Shaped Upper Tibial Osteotomy for Correction of Tibia Vara In Pediatric Age Group A Mid-Term Follow-Up Study

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Abstract. Aims: To evaluate the outcome of dome-shaped high tibial osteotomy at the end of 24 months of follow up postoperatively using knee society, function score and knee alignment (HKA angel). Patients and methods: A sample of 21 patients (31 knee joints) with bilateral or unilateral genu varum of different etiology that was operated on between 1st. July.2014 - 31st.Dec.2015 in Al-Wasity Teaching Hospital by dome shaped high tibial osteotomy for correction of varus status and followed up for 24 months post-operatively for assessment of outcome of surgery was included in this study. Results: The mean of corrected angel on immediate post-operative assessment was 11.3° ±2.9 SD valgus (range 5–15°). This angle decreased to 6.4°±2.8 SD valgus at 24 months with 4.9° Loss of correction. The mean angel of correction was decreased by 3.1 ° to 9 month and 1.8 degree from 9 month to 24 months of follow up, and this difference concerning angel changes with time was statistically significant (p=0.01).We had 4 patients with unilateral varus due to Blount's disease were under corrected. The outcome as assessed by the knee society and functional score was either excellent or good with all patient's even those who were under correction also showed improvement in these score. No significant complications reported.

Highlights:

1. Evaluate dome-shaped high tibial osteotomy outcomes over 24 months.
2. Analyzed 31 knees with genu varum post-osteotomy in 21 patients.
3. Significant correction achieved; excellent/good functional outcomes; minor complications reported..

Keywords: genu varum, high tibial osteotomy, knee society score and faction score, HKA angle.

Introduction

Genu varum, commonly known as bowlegs, is the most prevalent knee deformity in the pediatric population. It occurs due to uneven weight distribution on the medial compartment of the knee, resulting in increased stress on the articular cartilage and subsequent damage, which can lead to recurrence after surgical correction. This condition may arise from physiological growth variations during infancy, pathological

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causes such as Blount's disease, metabolic disorders like nutritional or vitamin D-resistant rickets, skeletal dysplasias, trauma, or systemic conditions such as renal osteodystrophy(1,2),While physiological genu varum often resolves spontaneously by the age of two, pathological cases can cause significant functional and structural challenges, including lateral knee thrust, waddling gait, in-toeing, and secondary effects on the hip and ankle. Severe cases may lead to progressive knee misalignment, chronic pain, and long-term joint deterioration if left untreated (3,4).

High tibial osteotomy (HTO) is a widely accepted surgical approach for correcting severe genu varum, particularly in active individuals. This procedure aims to realign the knee joint by shifting the weight-bearing load from the affected medial compartment to the lateral compartment, alleviating symptoms, promoting cartilage healing, and preventing further joint damage. Among the various techniques, dome-shaped osteotomy has gained attention for its precision in correction, minimal invasiveness, and preservation of the structural integrity of the tibia. This procedure offers a tailored approach to address deformities, ensuring optimal alignment and function(5-7)

This study aims to evaluate the clinical and radiological outcomes of dome-shaped upper tibial osteotomy in children aged 4–12 years with unilateral or bilateral genu varum. By examining changes in knee alignment, functional scores, and overall recovery over a 24-month follow-up period, the research seeks to provide insights into the effectiveness of this surgical technique in addressing knee deformities and improving long-term joint health in the pediatric population(8-10)

Methods

Study design

Descriptive case control study carried out at Al-wasity Teaching Hospital

Time of sample collection: -

1st. July.2014 - 31st.Dec.2015 and time of follow-up post-op. 2 years.

Sampling technique:

A sample of 21 patients 13 males and 8 females with 31 knees with mean age 7.6 years old and age ranging (4-12) years old who were underwent dome shaped high tibial osteotomy for genovarum correction and followed for 24 months to evaluate the outcome of surgery were included in this study

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Preoperative planning

Data was collected regarding history taking include age and gender, history of present illness, past medical history, any comorbidity illness, and social history. The findings of general physical examinations (unilateral or bilateral involvement, stability that includes varus or valgus stability and anterolateral stability), range of motion, flexion contracture if present. Complete neurovascular examination of extremity, walking distance, climbing, and walking aids if present as well as the questionnaire items covered the focused history and focused examinations that related to orthopedic concerns that include the concomitant and associated orthopedic injuries, knee pain, joint line tenderness, and knee effusion.

Surgical Technique and Post-Operative Follow-Up

Surgical Technique:

*Preparation:

- The surgical instruments for high tibial osteotomy (HTO) were prepared, and the patient was positioned supine on a standard operating table.
- General anesthesia was administered, and a tourniquet was applied to the thigh.

*Incisions and Landmarks:

- Skin markers identified the tibial tubercle, posteromedial tibia, and joint line.
- A 3–4 cm incision was made on the posterolateral leg for fibular osteotomy.

*Fibular Osteotomy:

- A 1-cm section of the fibula was excised at the upper-middle or middle-lower third junction, depending on the degree of deformity. Larger corrections (>10°) necessitated excision at the upper-middle third to reduce resistance from the interosseous membrane.

*Tibial Osteotomy:

- A 1–2 cm incision posterior to the tibial tubercle and 1 cm distal to the joint line extended distally for 5–6 cm.
- Subcutaneous fascia was dissected to expose the anteromedial tibial surface. Retractors protected the patellar tendon, pes bursa, medial collateral ligament (MCL), and neurovascular structures.
- Guide K-wires were placed across the proximal and distal tibia to achieve the planned angular correction, verified by fluoroscopy.

*Osteotomy Procedure:

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- The tibial osteotomy was performed 1 cm below the tibial tubercle using an oscillating saw, with fluoroscopy ensuring accuracy.
- An osteotomy wedge was inserted, and the site opened to the desired correction, monitored via fluoroscopy.
- A plate was inserted, sloped anterior to posterior, and secured with 4.5 mm cancellous screws (proximal fragment) and bicortical screws (distal fragment).

*Closure:

- The pes bursa was repositioned anatomically, subcutaneous fascia and tissues were closed with Vicryl sutures, and the wound was closed.
- A back slab was applied from above the knee to the foot sole for six weeks.

Post-Operative Follow-Up:
*Three Weeks Post-Operative:

- Wound inspection, pain assessment, and range of motion evaluation.
- Sutures were removed, and early complications were managed.
- The back slab was replaced with a plaster of Paris (P.O.P.) cast.

*Six Weeks Post-Operative:

- P.O.P. cast removed, and radiographs were taken.
- Physiotherapy commenced to restore knee function.
- Late complications were assessed, and knee alignment was evaluated.

*Long-Term Follow-Up:

- Visits at three and six months post-operatively included physical assessments, X-rays, and evaluation of knee society scores.
- Complications were monitored, and knee alignment and function were assessed up to two years post-operatively.

Surgical Goals and Protocols:

- The target was an 8°–12° valgus correction to avoid varus deformity progression.
- Over-correction up to 15° was performed to prevent future complications but avoided exceeding this to prevent valgus deformity.
- For bilateral knee deformities, the surgery prioritized the worse side or the dominant leg in equally severe cases.

Assessment Metrics:

Knee society scores were calculated based on pain, flexion range, contracture, stability, and functional ability (walking, stair use, and need for aids).

Ethical issue

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Obtained from concerned authorities (parents), name of the patients was kept hidden

Statistical analysis

SPSS version 23 is used for data entry and analysis. Normality tested by using the Kolmogorov-Smirnov statistic. Independent student T test and Anova test used to confirm.

Result and Discussion

The results showed that the mean age was7.6±3.6 SD, 61.9% was male and 38.1% was females. Nearly half of the patients (47.6%)had Blount's disease , 33.3% had rickets disease while 19.4% of cases were post traumatic .The results indicated that 60% of cases of Blount's disease was bilateral , 57.1% of Ricket cases was bilateral and all cases of posttraumatic was unilateral. The distribution of cases according to etiology and side of involvement, the results revealed that 56.2% of Blount's disease cases with right knee involvement, 54.5% of rickets disease cases was with left side involvement and 75% of post-traumatic cases with right side involvement as displaced in table 1, 2

Table 1.discrptive characteristics of studied group

No. of patients	Age (years old)	Mean/year		SD
		7.6		3.6
		Gender	Etiology	Site
1	5	Male	Blount's	Bilateral
2	4	Female	Blount's	Bilateral
3	5	Female	Blount's	Bilateral
4	4	Male	Blount's	Bilateral
5	4	Female	Blount's	Bilateral
6	7	Female	Blount's	Bilateral
7	5	Female	Blount's	Unilateral
8	8	Female	Blount's	Unilateral
9	7	Male	Blount's	Unilateral
11	6	Male	Blount's	Unilateral
11	6	Male	Ricket	Unilateral
12	8	Male	Ricket	Unilateral
13	9	Male	Ricket	Unilateral

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14	11	Male	Ricket	Bilateral
15	7	Male	Ricket	Bilateral
16	9	Female	Ricket	Bilateral
17	11	Male	Ricket	Bilateral
18	12	Female	Post-trauma	Unilateral
19	10	Male	Post-trauma	Unilateral
21	12	Male	Post-trauma	Unilateral
21	10	Male	Post-trauma	Unilateral

Table.2.distribution of studied group according to gender, etiology and site of joint involvement

			No.	%
Gender(n=21)	Female		8	38.1
	Male		13	61.9
Etiology/patients/biui(n=21)	Blount's(n=10)	Bilateral	6	60.0%
		Unilateral	4	40.0%
	Rickets(n=7)	Bilateral	4	57.1%
		Unilateral	3	42.9%
	Posttrauma(n=4)	Unilateral	4	100.0%
Etiology/site/joints (N=31)	Blount's(16)	left	7	43.8%
		right	9	56.2%
	Rickets(n=11)	left	6	54.5%
		right	5	45.5%
	Posttrauma(n=4)	left	1	25.0%
		right	3	75.0%

The knee society score and functional score assessed pre-operatively, at 9 months postoperatively to include the outcome of second surgery in assessment for patients with bilateral involvement and at the end of 24 months postoperatively. The

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results revealed that knee society score and functional score dramatically improved with time as seen in table 3

Table.3. society and functional knee score pre-op, 9/months and 24 months of follow up where first No. is society score and second No. is functional score

Patient no.	Bilateral/unilateral	Pre-op.	9 /months	24/ months	outcome
1	bilateral	7/10	75/80	93/100	Excellent
2	bilateral	2/5	84/80	93/100	Excellent
3	bilateral	13/15	71/70	82.5/85	Excellent
4	bilateral	6/13	51/55	78.50/80	Excellent
5	bilateral	5/25	61/60	74/75	Good
6	bilateral	8/5	69/70	86/95	Excellent
7	bilateral	18/10	80/80	94.5/100	Excellent
8	bilateral	11/15	78/80	94.5/100	Excellent
9	bilateral	10/25	83/80	92.5/95	Excellent
11	bilateral	4/10	64/55	77.5/75	Good
11	unilateral	24/25	60/65	79.5/85	Good/ Excellent
12	unilateral	15/15	80/70	92.5/90	Excellent
13	unilateral	10/5	83/75	95/100	Excellent
14	unilateral	21/25	48/75	72.5/80	Good/ Excellent
15	unilateral	5/25	80/90	95/100	Excellent
16	unilateral	4/25	77/80	81/85	Excellent
17	unilateral	25/21	78/70	82/90	Excellent
18	unilateral	38/20	39/45	71/75	Good
19	unilateral	5/15	69/80	74/82	Good/ Excellent
21	unilateral	16/10	68/65	92.5/95	Excellent
21	unilateral	27/45	73/90	84.5/100	Excellent

The results of current study indicated there was no significant difference(p=0.7,0.4) respectively for knee society score and functional score when compared according to status of involvement in term of bilateral or unilateral where the scores were improved in similar manner in patient with unilateral or bilateral

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Table 4. Mean value of knee society score and functional knee score according to status of involvement

	Site	N	Mean	Std. Deviation	p-value
knee society score	unilateral	11	89.2	8.7	0.7
	bilateral	10	90.5	10.6	
Functional score	unilateral	11	83.4	9.1	0.4
	bilateral	10	86.6	7.9	

The finding showed that the mean value of knee society score was significantly differed with time where the mean value of score at 24 months of follow up was significantly higher than that of 9 months and pre-operative assessment (p=0.01) as seen in table 5

Table.5. mean value of knee society score, pre-op, at 9 months and 24 months of follow up

		N	Mean	SD	p-value
knee society score(pre-op)	Pre-op	21	12.5	9.8	0.01
	9 months	21	70.0	12.3	
	24 months	21	84.9	8.5	

The finding showed that the mean value of functional score was significantly differed with time where the mean value of functional score at 24 months of follow up was significantly higher than that of 9 months and pre-operative assessment (p=0.01) as seen in table 6

Table.6. Mean value of functional knee score, pre-op, at 9 months and 24 months of follow up

		N	Mean	SD	p-value
Functional score(preop)	Pre-op	21	15.7	10.8	0.01
	9 months	21	72.1	11.5	
	24 months	21	89.8	9.4	

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The results revealed that the H-K-A Angele was corrected to desired angle in majority of cases (87.1%) but under corrected was reported with 4 cases only (12.9%) .The results showed that the angle at 24 months of follow up was less than 185 degree (degree of correction< 15 degree valgus) as seen in table 7

Table.7. H-K-A angle pre-op, immediately post op, 9 months and 24 months of follow up.

	Pre-op	Immediately post -op	9 months	24 months
1	170.00	194.00	190.00	188.00
2	166.00	185.00	180.00	178.00
3	169.00	192.00	188.00	188.00
4	167.00	184.00	181.00	179.00
5	165.00	190.00	187.00	185.00
6	168.00	192.00	190.00	189.00
7	167.00	193.00	189.00	187.00
8	170.00	195.00	191.00	187.00
9	168.00	192.00	190.00	189.00
11	168.00	184.00	183.00	177.00
11	168.00	192.00	190.00	190.00
12	167.00	193.00	189.00	187.00
13	166.00	190.00	188.00	187.00
14	167.00	189.00	186.00	185.00
15	167.00	189.00	187.00	186.00
16	169.00	184.00	182.00	178.00
17	166.00	193.00	190.00	189.00
18	168.00	191.00	188.00	186.00
19	169.00	190.00	189.00	188.00
21	168.00	192.00	190.00	190.00
21	168.00	192.00	189.00	186.00
22	167.00	195.00	190.00	189.00
23	168.00	195.00	190.00	188.00
24	168.00	195.00	190.00	186.00
25	170.00	188.00	187.00	187.00
26	168.00	195.00	190.00	188.00
27	168.00	195.00	190.00	187.00

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28	168.00	192.00	191.00	190.00
29	166.00	194.00	193.00	190.00
31	166.00	193.00	190.00	188.00
31	168.00	191.00	189.00	187.00

All the knees joints were varus preoperatively with a mean angle of 12.4±1.3 SD and the corrected angel ranged from 15-25 degree. The mean of corrected angel on immediate post operatively assessment was 11.3 ±2.9 SD valgus (range 5–15). This angle decreased to 6.4±2.8 SD

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valgus at 24 months with 4.9 Loss of correction with time. The mean angel of correction was decreased 3.1 from immediate post-operative time to nine months and 1.8 degree from nine month to 24 months of follow up, and this difference was statistical significant (p=0.01).

We had 4 patients with unilateral varus due to Blount's disease were under corrected as well as they are neglected patients and did not follow our orders where they got mobilized early at 3 weeks post op so their outcome was not good with pre-operative postero lateral capsule complex laxity .

Our data, indicated that the mean value of H-K-A angel was significantly differed (p=0.01) with time sequence (pre-op to 15 months. It was increased to 191.3 degree on immediate post-operative assessment then decreased to 188.2 degree on 9 months of assessment and lastly to 186.4 degree at the end of 24 months of follow up as shown in table 8

Table.8. Mean value of H-K-A angel at pre-op, immediately post-op, at 6 months and 15 months of follow up

		N	Mean	SD	p-value
H-K-A angel	Pre-op	31	167.4	1.7	0.01
	Post-op	31	191.3	2.9	
	9 months	31	188.2	3.0	
	24 months	31	186.4	3.0	

Table .9. Results of complication

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complication	No. of cases	Percentage of 31 knees
C.P.N. palsy	zero	Zero
Superficial wound infection	3	9,6%
DVT	zero	Zero
Compartment Synd.	zero	zero
Non union	zero	zero
Recurrence	4	12,9%
osteomyelitis	zero	zero

Discussion

The dome osteotomy technique first known as Maquet type-high tibial osteotomy but Blaimont (11,12) is the first author who described the modification on this technique. The most important advantages of dome type high tibial osteotomy is that it can remedy large angular deformities so it provides decompression of the patella-femoral joint and also allows for postoperative corrections as well as this type of surgery provides flexibility of choosing postoperative alteration in correction if necessary. In addition, it does not require resection of the tibia and does not result in shortening of the limb. A small midline incision also proves to be advantageous (13)

In this study, the knee society score and functional score were significantly improved with time post operatively in all cases even that with under correction. The mean score was significantly differed when compared on different time of follow up (pre-o-, 9 and 24 months), where the final knee society score was improved from 12.5 preoperatively to 84.9 on assessment at 24 months of follow up. The same improvement reported with functional score where it was changed form 15.7 preoperatively to 89.8 at 24 months of follow up. Among our cases.

No. of cases	Society score	Functional score
3	good	good

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15	Excellent	Excellent
3	Good	Excellent

According to these finding; we revealed that the alignment obtained after HTO does not had great influence on knee and functional scores if it was within an acceptable range. Chiang et al (14). Used domeshaped HTO and external fixation to treat 25 knees with varus knee joint and the findings for knee society score was excellent or good in 18 knees at five years of follow up and in 13 knees at an average of 15 years. This author showed that the knee society and function score of knee performance was 88 ± 9 at 5 years after the surgery, and they reported excellent or good performance in 94.73% of their cases(15).

We reported good results in 87.1% of cases regarding alignment on mid-term follow up for 24 months, same good results but with long-term follow up reported by Krempen and Silver (16) that obtained good-very good results in 84 % of 40 cases.

Sundaram et al (17) obtained good results in only 18 out of 105 cases regarding the desired mechanical correction using staples ,in addition they stated that a good level of pain control was achieved for over five years in most of the cases and that good-very good results were obtained in 75 % of the cases.

In this study, the results showed that the mean of corrected angel immediately post-surgery was 11.3-±2.9 SD valgus (range, 5–15). This angle decreased to 6.4±2.8 SD valgus at 24 months with 4.9 Loss of correction, so the mean angel of correction was decreased by 3.1 degree at nine months, 1.8 degree from nine months to 24 months of follow up post operatively, and this difference was statistically significant (p=0.01). All 4 patients with under correction were belonged to patients with unilateral varus Blount's and they had preoperative posterolateral capsular complex laxity. In addition, they reported good outcome for knee society score and functional score.

Our finding for decreased degree of correction with time was in consistent with the results of Kodkani P S et al. (18). These authors had linked the over or under correction and outcome status to the fixator type that used where they stated; although the Ilizarov fixator has shown excellent results concerning accuracy in achieving and maintaining the correction, the uniplanar fixators have resulted in a large percentage of over- or under-correction and relatively low "excellent" outcomes. Our data was partly

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in line with the results of Chiang et al (19) that has found in their study the actual postoperative alignment averaged 12.4° valgus and degree of correction was decreased significantly to 7.8° valgus after 5 years of follow up. The results of Kodkani (20) study showed all patients, who underwent dome-shaped osteotomy achieved optimal bone corrections, except one case that had 5° of under-correction where they linked this under correction status to pre-operative posterolateral corner laxity.

Our data concerning the degree of correction (15-28°) with 11.3° valgus postoperatively nearly similar to results of Geith and Naggar(21) where they achieved angle of correction between 19 and 26° with 5° 15° valgus after dome-shaped osteotomy.

According to Kodkani P S (22), the perfect site of fibular excision is depending on degree of deformity. Therefore for the deformity that need correction>10 degree, the fibula better to be excised at junction of upper and middle third to prevent resistance in alteration of correction by the interosseous membrane and overlapping of the fibula and for <10o varus the excision was performed at the lower-middle third junction. Both Elgafy et al (23) identified a „danger zone" between 6 and 13 cm distal to the head of the fibula where the risks of damage to the nerve to extensor hallucis longus muscle which has a close relationship to the fibular periosteum at this site.

In our study; 3 cases presented with superficial wound infection but no others suspected complications such as mal union or no union, DVT, etc. was observed. These findings partly correspond with the results of Kodkani (24) where in their study, the superficial pin tract infection reported with three cases only and all osteotomies fused in 6-8 weeks without any complications.

Hypostasis on the dorsal surface of the patient"s leg in other case that disappeared after the follow-up period. The alignment of the limb was not corrected completely in two cases on 6-month of follow-up and had a varus of 2-4°. Backstein D et al (25) had reported that, one of the prevalent complications in patients treated with dome-shaped osteotomy is the incidence of permanent palsy in peroneal nerve and/or temporary paralysis of the extensor hallucis longus muscle, which causes dissatisfaction of patients treated with this method of osteotomy

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Conclusion

- Dome-shaped procedure has favorable treatment outcomes
- effective and safe method for the correction of genu varum deformity

Recommendations

It is advised for studies with longer-term follow up and larger sample sizes for accurate assessment of the outcomes

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