



TREATMENT OF GENU VALGUM IN CHILDREN METHOD OF TEMPORARY HEMIEPIPHYSIODESIS USING EIGHT-PLATES: SHORT-TERM OUTCOME

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Abstract:

Background: Angular deformities of the lower extremities cause activity-related pain, altered gait mechanics, and joint instability, and these are exacerbated by periods of growth. Conservative usually fails to correct deformity; correction of deformity by hemiepiphyodesis has become the standard surgical technique of treatment.

Objective: The aim of this study to evaluate temporary hemiepiphyodesis around the knee to modulate growth with eight-Plate technique in patient with genu valgum.

Material and method: A prospective study between January 2015 and December 2019, we evaluated the patients as a single group to assess the effectiveness of temporary hemiepiphyodesis as a method of correction of genu valgum. The study included 29 patients with one patient was male and had unilateral valgus left knee and was lost in the follow up after removal of the plate and the remaining 28 patients were 22 bilateral 78.6% and 6 unilateral 22.4% (50 knees) four patients with right side 14.3% and two patient left side 7.1% with coronal genu valgum deformity indicated for surgical treatment. There were 19 boys (67.8%) and 9 girls (32.2%) and all of them were treated by temporary hemiepiphyodesis using eight-plate technique. The mean average age of the children at a time of the operation was 7.8 ± 2.3 years (range, 4–12.5 years).

Result: The entire patient had complete correction of the deformity. The mean follow-up was 31 ± 7.8 months (range 20-48 months) after plate removal. Two patients reached skeletal maturity at the final follow up. The eight-plates were inserted on the medial distal femur (MDF) in 6 patients (21.4%), in proximal tibia (MPT) in 6 (21.4%) patients and on both femur and tibia (MPT+MDF) in 16 patients (57.2%). All patients achieved complete deformity correction after plate removal mean duration 19 ± 4.6 months (14-29 months) and the mean Intermalleolar distances before the procedure was 19.2 ± 4.3 changed postoperative to 1.2 ± 1 with P value > 0.001 and the mean mL DFA changed from 79.2 ± 5 to 87.2 ± 1.5 and the P value > 0.001 after the procedure.

Conclusion: Temporary hemiepiphyodesis using eight-Plates is a delicate, straight forward and successful strategy used to treat genu valgum by modulating growth. Slight overcorrection is alluring because of the rebound phenomenon, particularly in young patients with high development potential and risk groups, for example, obese children.

Key words: Hemiepiphyodesis, Eight-plate, Genu valgum, Growth modulation

INTRODUCTION

Pathologic genu valgum can be either an idiopathic, present terrible due on physeal harm and development capture, metabolic, neuromuscular disarranges, after diseases acquired scatters. One-sided valgus deformation as a rule had a basic reason as, tumor, disease, old malunited crack at the distal femur or proximal tibia, old physeal injury, old

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orthopedic medical procedure, metaphyseal dysplasia, fibular hemimelia, or numerous epiphyseal dysplasia.(1) The closure of distal end of Femur in male usually at 18-19 years of age, and in females had epiphyseal closure at 16-17 years age. In proximal end of Tibia male had epiphyseal closure at 17-18 years age however in females had epiphyseal closure at 16-17 years age.(2) In children the knee changed from varus knee and decrease till it is reversed to valgus knee and increase to 10-15° valgus degrees at the age of four years then it starts to decrease over next two years reaching adult level (7 degrees valgus). (3,4)

In 2004, Stevens suggested the use of two-screw plates to temporarily block the bone growth plate. This method involves the placement of an extraperiosteal plate at the level of the particular growth plate segment, either at the summit or in the plane of the deformity.(5) This method was prospectively described as the “eight-plate guided growth method” According to most authors who have applied this method, its advantages relative to staples and transphyseal screws include minimal invasiveness, higher accuracy, greater comfort, better reliability, and improved efficiency as well as an insignificant risk of complications.(6)

Radiographic evaluation was including measurement of the lateral distal femoral angle (LDFA), anatomic femoral tibial angle (FTA), mechanical axis (MA) passing through center of the femoral head to center of the ankle and its deviation in relation to knee center. Clinical examination of patients including type of gait ,discrepancy in limb length of lower limbs, patellofemoral joint for alignment and stability, presence of ligament laxity ,presence of chondromalacia patellae, increase Q-angle ,and contracture of iliotibial band in paralytic disorders (7).

Non-surgical treatment of genu valgum indicated in cases with femurotibial angle less than 15 degrees valgus by bracing and follow up which usually non satisfactory in pathological cases of genu valgum. The surgical treatment include two surgical methods either hemiepiphyseal using staples or plate and screws, and transphyseal screws percutaneous which indicated in patients more than 15-20 degree of valgus in children less than 10 years of age (8). The other surgical technique is distal femoral varus osteotomy either medial closing or lateral opening wedge osteotomy, medial transverse osteotomy with hazards of complications nonunion and Peroneal nerve injury (9).

Different methods of around knee osteotomy and may be revised for correction of genu valgum deformities in growing children as deformity may recur. Complications after knee osteotomies presented as knee pain, stiffness, non-union, malunion and delayed mobilization. Disadvantages and complications of osteotomies can be decreased or prevented by using the Guided growth plate method for correction of deformities which is a flexible construct of 8 plate and two screws aiming for hemiepiphyseal by using safe and effective surgical technique for correction such angular deformity.(10)

Inclusion criteria in this study was skeletally immature patients with coronal plane deformity around the knee with genu valgum either idiopathic or pathological causes. Exclusion criteria were skeletally mature children, children’s age less than two years before physeal closure and skeletal maturity, physiologic genu valgum deformity and valgum deformity due to ligamentous laxity and soft tissue imbalance presented in neuromuscular diseases.

PATIENTS AND METHODS

From January 2015 and December 2019, we evaluated the patients as a single group to assess the effectiveness of temporary hemiepiphyseal as a method of correction of genu valgum. The included 28 patients were 22 bilateral 78.6% and 6 unilateral 22.4% (50 knees) four patients with right side 14.3% and two patient left side 7.1% with coronal genu valgum deformity indicated for surgical treatment. There were 19 boys (67.8%) and 9 girls (32.2%) and all of

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them were treated by temporary hemiepiphyodesis using eight-plate technique. The mean average age of the children at a time of the operation was 7.8 ± 2.3 years (range, 4–12.5 years) (table 1).

They were treated by temporary hemiepiphyodesis method using the eight-plate (8-plate) technique using two holes one third tubular plate with 3.5-mm cannulated screws.

The inclusion criteria of this study was one or more of the following criteria: first, an overall coronal plane deformity valgus ≥ 20 as per Tibiofemoral angle (TFA) that is persistent or worsening over the past 6 months, second, a mechanical axis deviation (MAD) bisecting the knee outside the central one-third of the transverse diameter of the proximal tibial epiphysis, and third, a clinically symptomatic gait impairment in the form of troublesome circumduction gait in association with genu valgum or frequent falls. Exclusions criteria were previous guided growth surgery or osteotomy on the affected limb, osteochondrodysplasias, endocrinopathies, and infectious deformities, and all forms of resistant rickets. The study was approved by our institution's Ethical Committee of Scientific Research.

PREOPERATIVE ASSESSMENT

The patient's clinical evaluation included limb lengths measurement, measuring of rotational and angular deformities with evaluation of the gait. The patellar tracking and any ligamentous laxity were recorded. Children with clinically obvious knock knees and an enlarged Intermalleolar distance (> 10 cm) and with increasing valgus despite conservative therapy had their legs X-rayed anterior-posterior standing up. The determination of the Intermalleolar distance to > 10 cm is an internal clinical standard which has proved itself for years. It serves as an orientation and is shared with the increasing valgus deformity in conservative therapy.

The mechanical axis deviation (MAD) from the knee joint was recorded for all cases. It was drawn from the center of the hip to the center of the ankle passing by the knee joint as shown in (Fig 1).

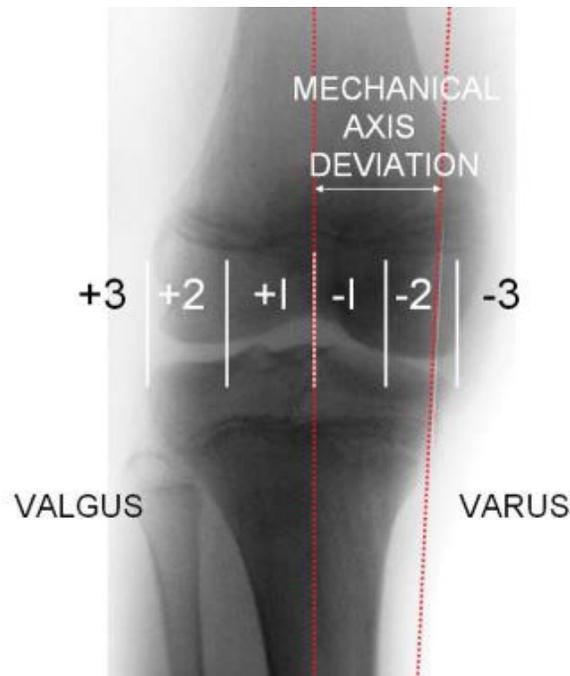


Figure1. Zones of mechanical axis deviation of knee in angular deformity

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As the mechanical axis normally bisecting the knee, the knee is divided into 4 zones when zone 1 is normal, if the mechanical axis displaced into zone 2 or 3 it is an indication for intervention, especially when the deformity is progressive and symptomatic. To determine the origin of the deformity (femoral, tibial or combined), the mechanical lateral distal femoral angle (mLDFA) and the medial proximal tibial angle (MPTA) were measured for all patients as shown in (Fig 2).

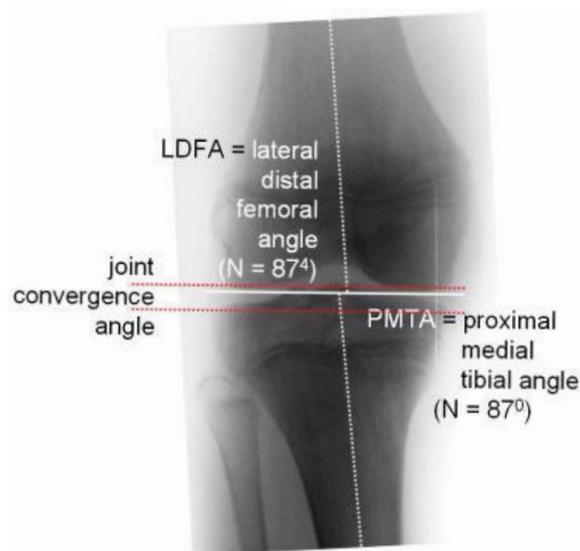


Figure 2. Lateral distal femoral angle(LDFA),proximal medial tibial angle(PMTA)

When indicated, the multiplier method was used to determine if there is sufficient predicted growth remaining to achieve the desired correction through guided growth.

In the event of pathological angles, an assessment was carried out as to whether medial distal femoral and/or medial proximal tibial hemiepiphyodesis or both should be carried out.(11)

Operative Technique

As a day case surgery, all cases were operated on under general anesthesia, in the supine position with the application of a tourniquet of the affected side. Under C-Arm fluoroscopic radiation, 3 cm long skin incision opposite the physis was done medially then the dissection was done through the fascia, between muscles, without elevating the periosteum. To localize the physis, a needle was inserted through the perichondrial ring under fluoroscopy. The plate of 12 or 16 mm was chosen, then threaded guide pins were inserted through the centers of holes of the plate. A cannulated drill bit of 3.2 mm caliber was used over the guide wire, and then two 4.5-mm self-tapping cannulated screws were applied with lengths of the screw does not pass the midline. After securing the screws, the wound was closed and the compression bandage was applied.

Starting rehabilitation on the second postoperative day including quadriceps strengthening exercise, increasing range of motion of the knee and starting walking as tolerated by the children. After removal of stitches, full weight bearing was started. After 2 weeks of operation full activity was allowed. Follow up every 2 month till reaching the final correction of the deformity and restoration of normal mechanical axis of the affected limbs. At this time the plate and screws was removed.(fig. 3)

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Figure 3: A, preoperative clinical picture of the patient/B ,preoperative scanogram/C, postoperative x-ray / E and D final clinical picture and scanogram for the patient

RESULT

Between January 2015 and December 2019, twenty eight patients (19 boys 67.8% and 9 girls 32.2%) with 50 valgus knee deformities with twenty two cases with bilateral knee deformity (44 knees 88%) and six cases with unilateral (6 knees 12%) and the mean age of the cases at the time of the operation was 7.8 ± 2.3 (4-12.5 years).(**Tab.1**)

Table (1):-Demographic& clinical characteristic of the studied patients (No.=28).

		Mean ± SD	Range
Age (years)		7.8±2.3	4-12.5
Duration of correction		19±4.6	14-29
FU (months)		31±7.8	20-48
		No.	%
Sex	Male	19	67.8
	Female	9	32.2

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Side	Bilateral	22	78.6
	Right	4	14.3
	Left	2	7.1
Pathology	Idiopathic	11	39.3
	Post-rachitic	12	42.9
	Post traumatic	5	17.9
Site of HEMIEPIPHYSIODESIS	MPT+MDF	16	57.2
	MDF	6	21.4
	MPT	6	21.4

The mean follow-up was 31±2.3 months (range 20-48 months) after plate removal. Two patients reached skeletal maturity at the final follow up. The eight-plates were inserted on the medial distal femur (MDF) in 6 patients (21.4%) Ten knees (20%), in proximal tibia (MPT) in 6 (21.4%) nine knees (18%) patients and on both femur and tibia (MPT+MDF) in 16 patients (57.2%) Thirty one knees (62%).

All patients achieved complete deformity correction after plate removal mean duration 19±4.6 (14-29 months) and the mean follow up was 31±7.8 (20-48 months) and the mean Intermalleolar distances before the procedure was 19.2±4.3 changed post to average 1.2±1 (Percent of improvement 93.8%)(significant p. value > 0.001) and the mean mL DFA changed from 79.2±5 to 87.2±1.5 (Percent of improvement 10.1%) (Significant p. value > 0.001) after the procedure. Neutral mechanical axis with no MAD was the sign of complete correction. Alignment improved in all cases at final follow up and the Radiographic TFA mean changed from 22.3±4.7 to 7.8±4.6 (Percent of improvement 65.0%) (Significant p. value > 0.001) and the Radiographic MPTA changed from 92.6±3.7 to 87.8±0.9 (Percent of improvement 5.2%) (Significant p. value > 0.001).(tab. 2)

Table (2): -comparison between pre and post-operative results regarding different parameters of studied patients (No.=28).

	Pre –operative	Post –operative	Percent of improvement	Paired t test	p. value
	Mean ± SD	Mean ± SD	(%)		
Intermalleolar distance	19.2±4.3	1.2±1	93.8	29.104	<0.001**
Radiographic mL DFA	79.2±5	87.2±1.5	10.1	-9.668	<0.001**
Radiographic TFA	22.3±4.7	7.8±4.6	65.0	26.54	<0.001**
Radiographic MPTA	92.6±3.7	87.8±0.9	5.2	7.737	<0.001**

In cases when the deformity origin was femoral, (Table: 3)

Table (3) :-Demographic& clinical characteristic of patients with femoral deformity (No.=6).

		Mean ± SD	Range
Age (years)		6.7±2.3	4-10.2
Duration of correction		17.5±3.4	14-22
FU (months)		31.3±7.1	23-42
		No.	%
Sex	Male	5	83.3
	Female	1	16.7
Side	Bilateral	4	66.7
	Right	2	33.3
	Left	0	0.0

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Pathology	Idiopathic	0	0.0
	Post-rachitic	4	66.7
	Post traumatic	2	33.3
Site of HEMIEPIPHYSIODESIS	MPT+MDF	0	0.0
	MDF	6	100.0
	MPT	0	0.0

The mean age 6.7±2.3 (4-10.2) with mean duration of correction 17.5±3.4 (14-22) and mean follow up duration 31.3±7.1 (23-42). Mean mLDFA increased from 73.4±1.8 to 86.3±1.5 which constitutes an average change 17.6 and when the origin of deformity was tibial, the mean MPTA changed from 87.5±0.8 to 87.7±0.4. (Fig 5), (**Tab. 4**).

Table (4): -comparison between pre and post-operative results of patients with femoral deformity (No.=6).

	Pre –operative	Post –operative	Percent of improvement	Paired t test	p.value
	Mean ± SD	Mean ± SD	(%)		
Intermalleolar distance	15.6±1.7	0.3±0.4	98.1	20.357	<0.001**
Radiographic mLDFA	73.4±1.8	86.3±1.5	17.6	-14.946	<0.001**
Radiographic TFA	18.3±1.2	6.2±2.4	66.1	13.373	<0.001**
Radiographic MPTA	87.5±0.8	87.7±0.4	0.2	-0.61	0.568

In cases when the deformity origin was Tibial (**tab. 5, 6**), the mean Intermalleolar distance changed from 15.9±2.9 to 0.7±0.6 (Percent of improvement 95.6%) (Significant p. value > 0.001), Radiographic mLDFA changed from 83.6±6.7 to 87.6±0.6 Radiographic TFA changed from 18.1±1.8 to 4.6±3.2 (Significant p. value > 0.001) and Radiographic MPTA changed from 94.9±4.1 to 88.2±0.7 (Significant p. value > 0.001).

Table (5) :-Demographic& clinical characteristic of patients with tibial deformity (No.=7).

		Mean ± SD	Range
Age (years)		7.9 ±2.6	4.2-12.5
Duration of correction		20.1 ±3.8	14-25
FU (months)		31.3 ±6.2	26-42
		No.	%
Sex	Male	3	42.9
	Female	4	57.1
Side	Bilateral	4	57.1
	Right	1	14.3
	Left	2	28.6
Pathology	Idiopathic	0	0.0
	Post-rachitic	4	57.1
	Post traumatic	3	42.9
Site of HEMIEPIPHYSIODESIS	MPT+MDF	0	0.0
	MDF	1	14.3
	MPT	6	85.7

Table (6): -comparison between pre and post-operative results of patients with tibial deformity (No. =7).

	Pre –operative	Post –operative	Percent of improvement	Paired t test	p.value
	Mean ± SD	Mean ± SD	(%)		
Intermalleolar distance	15.9±2.9	0.7±0.6	95.6	16.113	<0.001**
Radiographic mLDFA	83.6±6.7	87.6±0.6	4.8	-1.597	0.161
Radiographic TFA	18.1±1.8	4.6±3.2	74.6	12.474	<0.001**
Radiographic MPTA	94.9±4.1	88.2±0.7	7.1	4.755	0.003*

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No intraoperative complications were recorded. Postoperative superficial infections were reported in one cases (3.57%) and treated by repeated dressing and IV cephalosporin antibiotics for 10 days and one patient developed limited ROM that improved by extensive physiotherapy, one had lower limb edema postoperative that recover after elevation of the lower limb and application of stockinet. No cases required any osteotomy or repeat the eight-Plate insertion until final follow up. (Table 2)

DISCUSSION

Genu valgum deformity alter the biomechanics of the knee by causing a distorted stress distribution on the weight-bearing surface of the knee joint, and various methods have been proposed to address this problem.

The guided growth methodology by means of transitory hemiepiphyseodesis is a system for amendment of angular deformations of the lower limb in kids (12). The formation of a tie on the convex side of the physis and resulting development from the unarrested side gives correction of the precise distortion. This method is a less invasive surgery accomplished with a low morbidity and can be suspended once the satisfactory alignment is acquired.(13) The idea of the eight-plate lies in the position of a non-rigid extra periosteal plate and two screws, filling in as a central pivot at the edge of the physis.(14)

The purposes of this study were to determine the accuracy of partial hemiepiphyseodesis in correction of genu valgum deformity by evaluating radiological outcome comparing the preoperative and postoperative measurements, the descriptive data on time spent with plate, mean correction time, and determine the safety and reviewing the complications.

In our study we had temporary hemiepiphyseodesis in twenty eight patients (19 boys 67.8% and 9 girls 32.2%) with 50 valgus knee deformities with twenty two cases with bilateral knee deformity (44 knees 88%) and six cases with unilateral (6 knees 12%) and the mean age at the time of the operation was 7.79 (4-12.5 years). The mean follow-up was 30.75 months (range 20-48 months) after plate removal.

All patients achieved complete deformity correction and the average duration 19 months (14-29 months), the average follow up was 30.75 months (20-48 months), the average Intermalleolar distances before the procedure was 19.2 cm (12.6-26.5) changed post to average 1.12 cm (0-3.6cm) and the average mL DFA changed from 79.11° (71.5°-88.2°) to 87.26°(83.6°-89°) after the procedure.

The study of **Ballal et al.** announced 13 patients (28 physes) with genu valgum deformity of mean period of 11.6 years. Patients were treated with the extra-periosteal application of 8 plates. The mean plate time of guided growth was 9.1 months (extend 8–16 months). Femoral genu varum disfigurement (mL DFA) remedied inside 5° of their ordinary mean qualities, while in tibial genu varum MPTA adjusted inside two degrees of their ordinary mean qualities, Correction was quicker if the children was under 10 years old. Complication in that study was one patient with plate and screw migration and one patient with deep infection who have surgical debridement but no permanent physal tethers were encountered after follow up patients between 6 and 32 months after plate removal.(15,16)

The study done by **Burghardt et al.** checked on guided growth in 10 patients (17 physes) with genu valgum deformity of mean age of 9.7 years utilizing 8 plates. The mean guided growth time was 8.5 months (6-15months). Site of correction were 3 limbs with both distal femur and proximal tibia deformity, 11 limbs with distal femur deformities. Femoral deformity (mL DFA) corrected within three degrees of their ordinary mean values, while MPTA corrected within 2° of their ordinary mean qualities with failure of correction in two patients. While failure of correction occur in two patients because of no enough growth remaining in the physes.(17)

Casteneda et al. reviewed guided growth in 24 patients (52 physes) with genu valgum deformity of mean age of 11.9 years using staples. Site of correction was 18 limbs with both distal femur and proximal tibia deformities, 7 limbs with distal femoral deformities and 9 limbs with proximal tibial deformities. Femoral deformity (mL DFA) corrected

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within 60 of their normal mean values, while MPTA corrected within 30 of their normal mean values with exclusion of 5 patients which failure of correction occur. And reviewed failure of correction occur in 5 patients, 5 patients with staple back out and one patient with superficial infection.(18)

Shin et al. reviewed guided growth in 19 (43 physis) patients with genu valgum deformity of mean age of 12.1 years for boys and 10.4 years for girls using staples. Site of correction was distal femur deformities, rebound deformity occur in three distal femoral physis.(19)

El-Batrawy et al in their study in which the use of 43 eight-plates for 22 patients with angular knee joint deformations and recently **Zajonz et al** in their series that included 198 eight-plates that were embedded close to the knee in 132 children experienced angular knee joint distortions had revealed great outcomes. Both found that guided growth with 8 plate procedure is end up being sheltered and compelling in the treatment of angular knee deformations with advantages over other procedures in children from 3 up to 12 years.(20,21)

Niethard applied eight-plates to correct knee joint axial deformities in children with an average age of 9.5 years (range: 2.3–13.7 years). **Burghardt** studied patients with ages ranging from 4.9 to 13.7 years. No growth plate complications were observed in these studies.(17,22,23)

Marangoz archived that there is connection, between the delta joint direction edge and the delta inter-screw angle. This connection isn't identified with the growth pace of the physis. It is an absolutely mathematical correlation, independent of the age and sex of the patient. It very well may be utilized to quantify the anatomical changes of the joint line without the need of full length X-rays. (24)

In this series 3 patients were over the age of 10 years and responded quite well to this technique. All cases in the current series had achieved full correction, but this was the preliminary results in a small sample size.

CONCLUSION

Temporary hemiepiphyseodesis using eight-Plates is a gentle, simple and effective procedure used to treat genu valgum by modulating growth. Slight overcorrection is desirable due to the rebound phenomenon, especially in young patients with high growth potential and risk groups such as obese children. In adolescents with only low growth potential (older than 14 years), owing to the low correction potential, the indication should be strictly reviewed and the possible failure of therapy should be discussed with the patient family.

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