

ARTÍCULO ORIGINAL / Original

## PERSISTENT TORSIONAL DEFORMITY IN PAEDIATRIC GENU VARUM AFTER CORONAL PLANE DEFORMITY CORRECTION BY 8-PLATE HEMI-EPIPHYSIODESIS

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### Abstract

**Introduction:** Angular deformities around the knee, i.e., genu varum and genu valgum, are common in children and can arise from various underlying conditions. Surgical treatment options include temporary hemiepiphysiodesis (guided growth), which is less invasive and carries fewer risks compared to traditional osteotomies. While effective for coronal deformities, the impact of this technique on persistent torsional deformities remains underexplored.

**Objectives:** This study aims to assess the persistent torsional deformity following complete correction of varus coronal deformity in pediatric patients treated with 8-plate hemiepiphysiodesis.

**Methods:** A retrospective case series study was conducted in a tertiary center from March 2023 to January 2025. The study included skeletally immature patients aged 2.5 to 12 years with genu varum deformity who underwent 8-plate hemiepiphysiodesis

for varus deformity correction. Clinical and radiological assessments-including foot progression angle, thigh-foot angle and heel bisector line- were used to evaluate rotational deformities after varus correction.

**Results:** A total of 26 limbs of 14 patients with mean age 4.54 years were analyzed. The mean duration of epiphysiodesis was 10.46 months. Despite successful correction of coronal deformities, 61.5% of patients exhibited persistent intoeing. The persistent torsion was of tibial source which was manifested in the foot progression angle and the thigh-foot angle.

**Conclusion:** While 8-plate is effective for coronal deformity correction in pediatric genu varum, a significant proportion of patients retain persistent torsional deformities.

**Keywords:** Intoeing, torsional deformity, genu varum, 8-pate hemi-epiphysiodesis, guided growth.

**Levels of Evidence:** Level of Evidence: III-retrospective observational study.



## **DEFORMIDAD TORSIONAL PERSISTENTE EN GENU VARUM PEDIÁTRICO DESPUÉS DE LA CORRECCIÓN DE LA DEFORMIDAD EN EL PLANO CORONAL MEDIANTE HEMIEPIFISIODESIS DE 8 PLACAS**

### **Resumen**

**Introducción:** las deformidades angulares alrededor de la rodilla, es decir, el genu varo y el genu valgo, son comunes en niños y pueden deberse a diversas afecciones subyacentes. Las opciones de tratamiento quirúrgico incluyen la hemiepifisiodesis temporal (crecimiento guiado), que es menos invasiva y conlleva menos riesgos en comparación con las osteotomías tradicionales. Si bien es eficaz para las deformidades coronales, el impacto de esta técnica en las deformidades torsionales persistentes sigue siendo poco explorado.

**Objetivos:** Este estudio tiene como objetivo evaluar la deformidad torsional persistente tras la corrección completa de la deformidad coronal en varo en pacientes pediátricos tratados con hemiepifisiodesis de 8 placas.

**Métodos:** se realizó un estudio retrospectivo de series de casos en un centro terciario entre marzo de 2023 y enero de 2025. El estudio incluyó pacientes esqueléticamente

inmaduros de entre 2,5 y 12 años con deformidad de genu varo, sometidos a hemiepifisiodesis de 8 placas para la corrección de la deformidad en varo. Se utilizaron evaluaciones clínicas y radiológicas, incluido el ángulo de progresión del pie, el ángulo muslo-pie y la línea bisectriz del talón, para evaluar las deformidades rotacionales después de la corrección en varo.

**Resultados:** se evaluaron 26 extremidades de 14 pacientes con una edad media de 4,54 años. La duración media de la epifisiodesis fue de 10,46 meses. A pesar de la corrección exitosa de las deformidades coronales, el 61,5% de los pacientes presentó marcha convergente persistente. La torsión persistente fue de origen tibial, manifestándose en el ángulo de progresión del pie y en el ángulo muslo-pie.

**Conclusión:** si bien la placa de 8 es eficaz para la corrección de la deformidad coronal en el genu varo pediátrico, una proporción significativa de pacientes conserva deformidades torsionales persistentes.

**Palabras clave:** marcha convergente, deformidad torsional, genu varo, hemiepifisiodesis de 8 placas, crecimiento guiado.

**Nivel de evidencia:** III-estudio observacional retrospectivo.

### **Introduction**

Angular deformities around the knee, i.e., *genu varum* and *genu valgum*, are frequently found in children. These deformities may be idiopathic or may arise secondary to various conditions as developmental disorders, trauma, skeletal dysplasia, metabolic or endocrine disorders, inflammatory diseases, or neoplastic processes.<sup>1,2</sup>

Surgical treatment options include temporary hemiepifisiodesis (guided growth), which is less invasive and has a far lower rate of serious consequences, and osteotomies with either acute or gradual correction.<sup>3,4</sup>

Coronal plane deformities of the knee are commonly managed using guided growth through 8-plate hemiepifisiodesis. Since its introduction by Stevens in 2007, tension band plating has been widely adopted as a safe and effective alternative to corrective osteotomy in the pediatric population. Multiple studies have demonstrated its efficacy, safety profile, and advantages in managing angular knee deformities in growing children. Growth modulation acts to create unilateral inhibition in frontal plane. Coronal plane deformity is typically two-dimensional, whereas torsional deformity

represents a three-dimensional rotational abnormality assessed in the transverse (axial) plane. Growth modulation induces differential spiral growth inhibition along the longitudinal axis of the bone.<sup>5</sup>

The causes of intoeing in children include metatarsus adductus, internal tibial torsion, and increased femoral anteversion. Among these, internal tibial torsion is frequently associated with genu varum deformities of the lower limbs. Here, intoeing is a compensatory mechanism for balance and part of a complex 3-D deformity.<sup>4</sup>

However, there is a paucity of literature evaluating the extent to which torsional deformities are corrected following 8-plate hemi-epiphysiodesis used for coronal plane deformity correction. This study was conducted to assess the persistent torsional deformity remaining after complete correction of coronal plane malalignment using 8-plate hemi-epiphysiodesis on the hypothesis that persistent torsional deformities are present after coronal plane correction.

## Material and methods

A Retrospective case series study was carried out on patients operated with 8-plate hemi-epiphysiodesis from June 2022 to January 2025 in a tertiary center. Local IRB No.:17101877 and clinical trial Registration No.: NCT05334862 were obtained. All patients and their legal guardians provided written informed consent according to the Declaration of Helsinki and good clinical practice (GCP) for publishing clinical photos.

*Inclusion criteria:* The study enrolled skeletally immature patients over 2.5 years of age and less than 12 years of age, who present idiopathic genu varum. *Exclusion criteria:* Child with one or more of the following criteria was excluded; skeletal maturity, epiphyseal dysplasia, metabolic and neurologic disorders, and/or previous trauma.

Basic demographic information (name, sex, age, medical and surgical history) was

collected. Clinical evaluation of rotational profile was performed by the following items, using a goniometer:

*-Foot progression angle (FPA):* the angle between foot longitudinal axis and imaginary straight line while walking- was estimated by footprint by chlorohexidine stain on the floor for 6 steps (Figure 1 and 2). FPA was considered normal if it is -5 to +20 degrees and persistent intoeing was considered less than - 5 degrees.

*-Increased femoral anteversion:* identified by increased internal rotation of the hip with decreased external rotation.

*-Thigh-foot angle:* to quantify tibial torsion (range of -5° to +30°).

*-Heel bisector:* to identify metatarsus adductus (medial deviation of the forefoot and normal hindfoot).<sup>6-8</sup>

Radiological confirmation of varus correction was done by standing long film X rays of both lower limbs. *These outcomes were independently assessed by two experts, and in case of discrepancies consensus was reached by discussions between them.*

*Surgical technique:* Under general anesthesia, patients underwent surgery with a supine position and the application of a tourniquet. A 2-3 cm longitudinal incision was made over the physis, guided by fluoroscopy, followed by the insertion of a 1.2 mm Kirschner wire into the physis. An 8-plate was then applied extraperiosteally, tailored to the deformity site (lateral distal femur, proximal tibia, or both). Using fluoroscopic control, 1.6 mm guidewires were inserted into the metaphyseal and epiphyseal regions while avoiding periosteal damage. The plate was secured flush against the bone with 3.5 mm fully threaded self-tapping cannulated screws, which were carefully drilled into place using a 2.5 mm cannulated drill bit, ensuring screw lengths did not exceed the midpoint of the respective bone regions. Final positioning was verified through anteroposterior and lateral imaging to prevent sagittal plane deformities,



after which the incision was closed in layers and a compression bandage was applied postoperatively.<sup>9</sup>

**Follow up:** the patients were allowed to perform early movement and full weight bearing as tolerated one day after surgery. Visits after two weeks were scheduled to detect any wound complication, then regularly every 3 months until clinically full correction, confirmed by standing X ray long film. Targeted correction was assessed by straight mechanical axis alignment; normal mechanical axis deviation (MAD) (4+/-2 mm medial to the center of the knee joint).

**Outcomes:** The primary outcome was to clinically assess amount and source, i.e. femur, tibia or foot, of persistent torsional deformity after full varus correction. Secondary outcome was to detect any complications detected such as infection, broken screws, broken wires.

**Statistical analysis:** Based on determining the main outcome variable, the estimated minimum required sample size was 23 limbs. The sample size was calculated using G\*power software 3.1.9.7., based on the following assumptions: the clinical measurements showed a highly statistically significant postoperative improvement. Effect size was estimated to be 0.8., Alpha = 0.05, Power = 0.95. Each limb was independently analyzed in bilateral cases through GEE (Generalized Estimating Equations) to handle the correlation between limbs (the “cluster”) without needing to model the specific distribution of every individual child.

Data was collected and analyzed using SPSS (Statistical Package for the Social Science, version 26 IBM, and Armonk, New York). The data was normally distributed according to the normality test, so parametric tests were used. Quantitative data with normal distribution were expressed as mean  $\pm$  standard deviation (SD). Nominal data were given as number (n) and percentage (%). Appropriate tests of significance were used.

The level of confidence was kept at 95% and hence, the *P value* was considered significant if  $< 0.05$ .

## Results

A total of 26 limbs of 14 (6 males and 8 females) patients were included. Twelve cases had bilateral varus deformity. Mean age at recruitment time was  $4.54 \pm 0.7$  years [Table 1]. The mean preoperative varus was  $26.8 \pm 10.97^\circ$ . Majority of them had epiphyseodesis by 8 plates both femoral and tibia ((24 out of 26 limbs) 92.3%) with average duration  $10.46 \pm 2.56$  months [Table 2]. After varus correction, all cases had normal average hip internal and external rotation and heel bisector line. The mean thigh foot angle was  $-9.9 \pm 7.6^\circ$ . At point of varus correction ten limbs (38.5%) had torsion corrected while others 16 limbs in 8 bilateral affected patients (61.5%) had persistent torsional deformity [Table 3, Figures 1-2]. There was a highly significant difference between patients with normal foot progression angle and those with persistent torsion in the following parameters; thigh foot angle (*P value* 0.002) and foot progression angle (*P value* 0.001). No complications were reported.

**Table 1.** Characteristics of the patients/ limbs

Category	Total
<b>Age in years, N</b>	14
Mean	$4.54 \pm 0.70$ SD
Min; Max	3-6
<b>Sex, N</b>	14
Male	6 (42.9%)
Female	8(57.1%)
<b>Laterality</b>	
Bilateral	12 (85.7%)
Unilateral	2 (14.3%)

Data expressed as frequency (percentage), and mean  $\pm$ SD (minimum to maximum)

**Table 2.** Coronal Deformity parameters

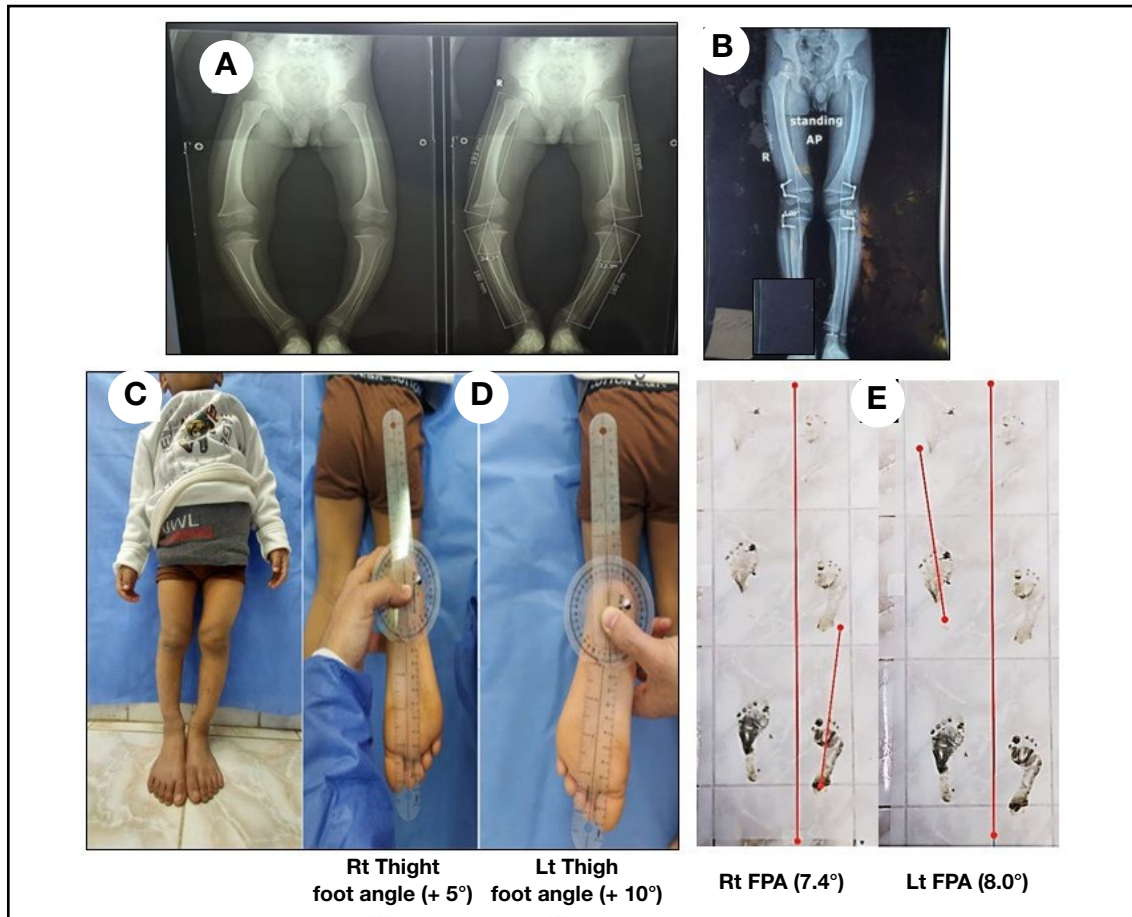
Category	Total
<b>MPTA (Preoperative), N</b>	26
Mean	76.65° ± 5.5° SD
Min; Max	(66.5-89°)
<b>LDFA (Preoperative), N</b>	26
Mean	107.7° ± 10.2° SD
Min; Max	(91-135°)
<b>Degree of varus (Preoperative), N</b>	26
Mean	26.8° ± 10.97° SD
Min; Max	(11-45.5°)
<b>Site of epiphysiodesis, N</b>	26
Femoral and tibial	24 (92.3%)
Femoral only	2 (7.7%)
<b>Duration of epiphysiodesis(months), N</b>	26
Mean	10.46 ± 2.56 SD
Min; Max	(7-15)
<b>Mechanical axis deviation (MAD)(Preoperative), N</b>	26
Mean	3.5±1.25 SD
Min; Max	(2-4.5)

Data expressed as frequency (percentage), mean ±SD (minimum to maximum), **MPTA** =Medial proximal tibial angle, **LDFA**=lateral distal femoral angle

**Table 3.** Rotational profile parameters

Category	Total
<b>Overall, Foot progression angle (FPA) (post),N</b>	26
Mean	-6.73 ° ± 8 SD
Min; Max	(-22 to 8)
<b>Limbs without intoeing after varus correction, N</b>	10 (38.5%)
FPA: Min; Max	(5 to 8°)
<b>Limbs with persistent torsion after varus correction, N</b>	16 (61.5%)
FPA: Min; Max	(-22 to-9 °)
<b>Hip internal rotation (post), N</b>	26
Mean	66° ± 6.6 SD
Min; Max	(45-75)
<b>Hip external rotation(post), N</b>	26
Mean	31° ± 2.6 SD
Min; Max	(30-40)
<b>Thigh foot angle (post), N</b>	26
Mean	-9.9° ± 7.6 SD
Min; Max	(-25 to 10)
<b>Heel bisector line (post), N</b>	26
Through 2nd and 3rd toe webspace	26 (100%)

Data expressed as frequency (percentage), and average±SD (minimum to maximum)



**Figure 1.** Improved case. Improved intoeing, with thigh-foot angle and foot progression angle within the normal range: (A) preoperative long-leg radiograph; (B) postoperative long-leg radiograph after final correction of genu varum; (C) clinical appearance after 8-plate removal following correction of genu varum; (D) thigh-foot angle; (E) foot progression angle.

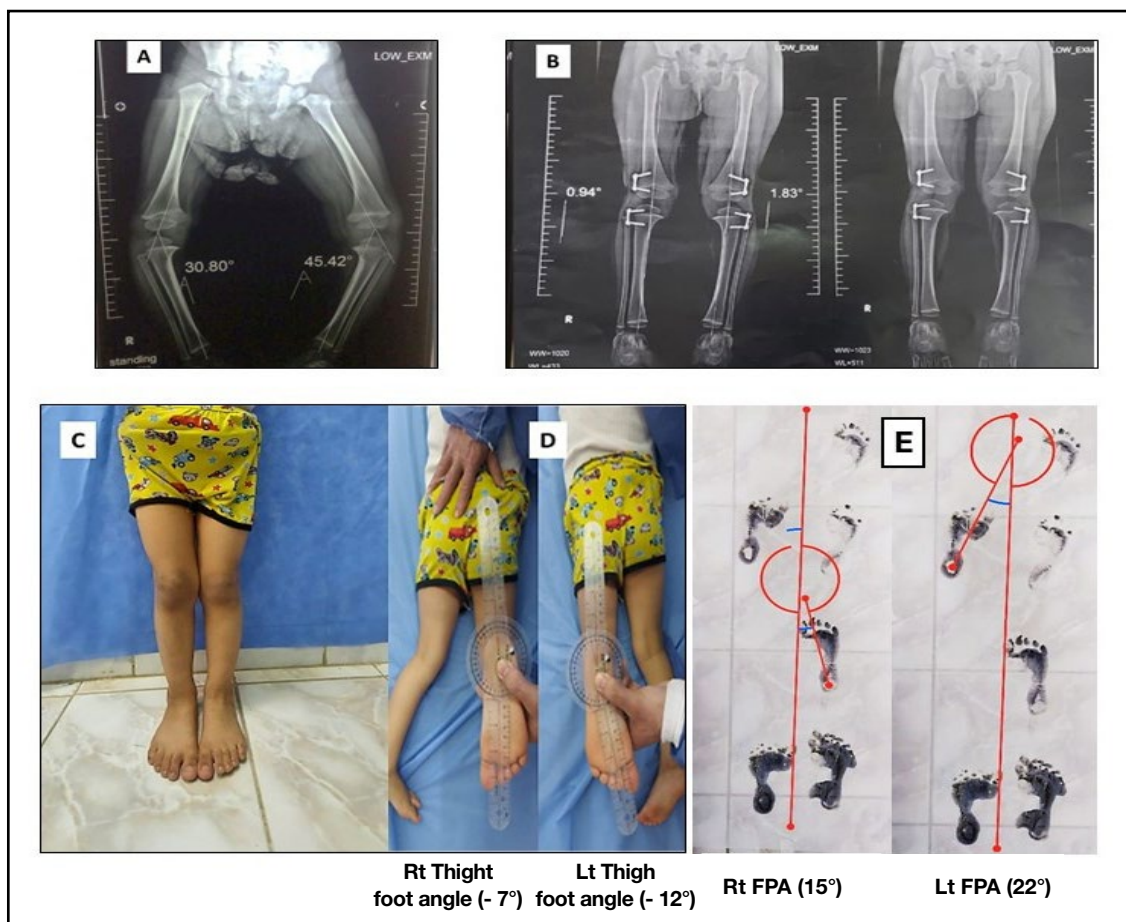
## Discussion

This study evaluated the effectiveness of 8-plate hemi-epiphysiodesis in correcting coronal plane deformities in pediatric patients with genu varum and assessed the persistence of persistent torsional deformities following correction. The mean age of participants was 4.54 years, which is within the optimal range for guided growth interventions. Normal children by age 4, the internal rotation seen in infancy should be usually corrected itself to a neutral position or a slight external rotation.<sup>5,4</sup>

Most cases involved bilateral genu varum, and the majority of patients underwent

epiphysiodesis at both the distal femur and proximal tibia. The average duration of implant placement was 10.46 months, representing a reasonable timeframe for achieving coronal alignment.<sup>5,10,11</sup>

While correction of the coronal plane deformity was successful across our study, persistent torsional deformities persisted in a significant proportion of patients (61.5%). A notable finding was the statistically significant difference in thigh-foot angle ( $p = 0.002$ ) and foot progression angle ( $p = 0.001$ ) between patients who achieved complete correction and those with persistent rotational



**Figure 2.** Case with persistent intoeing. Persistent torsion of tibial origin, with abnormal thigh-foot angle and foot progression angle: (A) preoperative long-leg radiograph; (B) postoperative long-leg radiograph after final correction of genu varum; (C) clinical appearance after 8-plate removal following correction of genu varum; (D) thigh-foot angle; (E) foot progression angle.

malalignment. These results suggest that isolated correction of the coronal plane does not necessarily result in resolution of coexisting torsional abnormalities.

This observation is consistent with prior studies indicating that rotational deformities may not spontaneously resolve following coronal alignment and may require targeted interventions, such as rotational osteotomy, in selected patients.<sup>12</sup>

Paley *et al.*<sup>13</sup> introduced a novel technique for rotational guided growth using inclined, counter-opposed peripheral flexible tethers. In their study involving eight bones in five

patients, this method achieved an average rotational correction of 30° in the femur and 9.5° in the tibia over a 12-month period, demonstrating promising potential for non-osteotomy-based torsional correction.

Halloum *et al.*<sup>12</sup> conducted a comprehensive review of 14 studies, encompassing both preclinical and clinical investigations, to evaluate the efficacy of rotational guided growth. Their findings indicated that while animal models demonstrated promising outcomes, clinical applications yielded inconsistent results. They emphasized the need for further clinical validation



of rotational guided growth techniques. While our study specifically assessed the persistence of torsional deformities after coronal alignment, our findings support their conclusion that guided growth, while effective for coronal correction, may not be sufficient as a standalone intervention for rotational deformities.

Zaidman et al.<sup>14</sup> investigated the use of rotational guided growth for the correction of femoral torsional deformities. Their study demonstrated significant clinical improvements through the use of obliquely placed 8-plates at the distal femur. Notably, they reported a reduction in the mean foot progression angle from 32° to 7°, and a correction in femoral version from an average of 60° to 22°, achieved over a mean treatment duration of 11 months. These results highlight the potential of guided growth techniques not only for coronal plane deformities but also for addressing femoral rotational malalignment.

Children younger than 6 years have higher liability to have axial deformity correction during guided growth for coronal plane deformity.<sup>13,9</sup>

One of the key strengths of this study is its focus on a clinically relevant and underexplored issue, tibial torsion correction in pediatric patients with genu varum using guided growth techniques. The use of objective, clinically validated outcome measures, such as foot progression angle and thigh-foot angle, enhances the methodological rigor and reliability of the findings.

This persistent torsional deformity is suggested to be regularly followed up and consideration of correction if not spontaneously resolved by rotational guide growths vs osteotomy if needed.

Several limitations must be acknowledged, including the fact that the study was conducted in a single center with relatively small sample size. Also, retrospective nature of the study increased the possibilities of recall bias. Major limitation was lack of preoperative

intoeing assessment to determine whether torsional deformity improved, worsened, or remained unchanged following surgery and non-independence of bilateral limbs. No longer duration of follow up to assess need for further intervention.

### Conclusion

This study demonstrated that while 8-plate hemi-epiphysiodesis is effective in correcting coronal plane deformities in pediatric patients with genu varum, a significant proportion of patients continue to exhibit persistent torsional deformities post-treatment without baseline rotational/intoeing data, the study can support persistence/prevalence, but not definitively that guided growth 'fails to correct' tibial torsion.

Future research should investigate the combined use of coronal and rotational guided growth techniques, assess long-term outcomes, and incorporate patient-reported functional measures to better evaluate the clinical impact of persistent deformities.

**Ethical approval:** IRB local approval number: 04-2022-300026

**Author Contributions:** Conceptualization, Methodology, Investigation (HME). Writing – Original Draft, Formal Analysis, Investigation (AN). Writing – Original Draft; Writing – Review & Editing (AKHI)

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