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Ultrasonographic features of pediatric umbilical hernias – associations with age, sex, and hernial orifice width

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ABSTRACT

Introduction and aim. Given the limited data on standardized ultrasound evaluation of hernial defect morphology in pediatric umbilical hernias, this study aimed to evaluate the ultrasonographic features of primary umbilical hernias in pediatric patients, with a particular focus on the width of the hernial orifice, the contents of the hernial sac and their potential correlation with age and sex.

Material and methods. A retrospective analysis of medical records of pediatric patients with primary umbilical hernia who presented to the pediatric surgery outpatient clinic and had ultrasonographic measurements performed using a standardized protocol between 01.01.2024 and 31.07.2025.

Results. Analysis of ultrasound measurements of the width of the hernial orifice width demonstrated a significant association between the width of the hernial orifice and the contents of the hernial sac. Children with intestinal loops present in the hernial sac were significantly younger than those with preperitoneal fat (p=0.016), and the width of the hernial orifice was greater in cases containing intestinal loops (p=0.028). In particular, among children with a hernial orifice larger than 14 mm, intestinal loops were observed more frequently than among those with an orifice width of 14 mm or less (58.82% vs 15.38%; p=0.026). Furthermore, the analysis revealed that the umbilical orifice was wider in boys than in girls (mean±SD: 15.44±1.64mm vs. 13.08±2.43mm; p=0.043).There was a difference between the width of the hernial orifice in children under 1 year of age and older.

Conclusion. Ultrasonographic evaluation of pediatric umbilical hernias provides clinically relevant information on the morphology of hernial defects. In particular, the width of the hernial orifice is associated with the presence of intestinal loops in the hernial sac, especially in younger children, with a threshold value of >14 mm identifying patients at higher likelihood of intestinal content. These findings suggest that ultrasonography may contribute to risk stratification and support clinical decision-making in the management and follow-up of pediatric umbilical hernias.

Keywords. anatomy, child, ultrasound, umbilical hernia

Introduction

Umbilical hernia is a common condition in the pediatric population.[1,2] Clinically, it presents as a bulge in the region surrounding the umbilicus. The condition called 'primary pediatric umbilical hernia" results from incomplete closure of the umbilical ring, a process that usually occurs after birth.[3] This closure involves complex developmental interactions, including medial folding of the lateral body walls, fusion of the rectus abdominis muscles to form the linea alba and contraction of the umbilical orifice.[3] Generally, a fascial defect that is present at birth resolves without surgical treatment.[3] While umbilical hernias are generally congenital, the term 'secondary pediatric umbilical hernia" can be applied to cases that arise as a consequence of prior surgical procedures.[4]

For the clinician, it is important that the extent of the skin protrusion is not always indicative of the size of the fascia defect.[3] Medical history and physical examination are important to assess the indications for treatment. However, they provide limited information regarding the morphology of the defect and hernial sac contents. Ultrasonography can be helpful in assessing the width of the hernial orifice and assessing the contents of the hernial sac, which is formed by the peritoneum. The hernial sac may contain an intestinal loop or preperitoneal fat.

Previous studies have relied primarily on clinical examination alone or have used nonstandardized or indirect methods to estimate defect size, without systematically correlating hernial orifice width with patient age, sex, or hernial sac contents. As a result, objective imaging-based parameters that may inform risk stratification and clinical decision-making remain insufficiently defined. In particular, the potential of ultrasonography to identify hernias more likely to contain intestinal loops – especially in younger children – has not been adequately explored.

In contrast to previous studies by Yanagisawa et al. Nakajima et al., and Kaur et al., which mainly relied on clinical assessment or nonstandardized imaging approaches, the present study provides standardized ultrasound measurements of the hernial orifice and directly correlates the width of the defect with hernial sac contents.[5,6,7] In addition, several previous reports did not consistently distinguish between primary and secondary umbilical hernias, reported the size of the defect using heterogeneous methodologies, or lacked complete quantitative data. By addressing these limitations, the current study extends existing knowledge by offering an imaging-based standardized evaluation of defect in relation to patient age, sex, and content of the hernial sac content.

Therefore, the objective of this study was to provide a standardized ultrasound evaluation of primary pediatric umbilical hernias and to evaluate the relationship between the width of the hernia orifice, the contents of the hernia sac, and the demographics of the patient, including age and sex. By correlating these parameters, this study seeks to clarify the clinical value of ultrasonography beyond descriptive imaging and

to explore its role in identifying children at increased risk of intestinal herniation. An additional objective of this study was to explore whether a measurable ultrasonographic cut-off value of the width of the hernial orifice could be identified, enabling differentiation between hernias containing intestinal loops and those containing preperitoneal fat. However, the proposed ultrasonographic threshold of the width of the hernial orifice should be regarded as exploratory and hypothesis-generating rather than definitive. Previous studies evaluating pediatric umbilical hernias have not reported standardized cut-off values for defect size, particularly in relation to hernial sac contents. However, identifying a preliminary imaging-based threshold may have potential clinical relevance as an objective marker to support risk-oriented monitoring in pediatric patients.

Aim

The objective of this retrospective study was to evaluate the ultrasound characteristics of primary umbilical hernias in pediatric patients, with a particular focus on the width of the hernial orifice, the contents of the hernial sac and their potential correlation with patient age and sex.

Material and methods

A single-center retrospective observational study with the analysis of medical records (including ultrasound examinations) performed in pediatric patients with primary umbilical hernia who came to the pediatric surgery outpatient clinic between 01.01.2024 and 31.07.2025.

Inclusion criteria

Pediatric patients (age from birth up to 18 years) were included if they met all the following criteria:

1. Diagnosis of primary umbilical hernia, defined as a hernia present from birth.
2. Evaluation at the pediatric surgery outpatient clinic during the study period (01.01.2024–31.07.2025).
3. Availability of a complete ultrasound examination of the umbilical hernia.

All consecutive patients with suspected primary umbilical hernia during the study period were included.

Exclusion criteria

Patients were excluded if they met any of the following criteria:

1. History of previous abdominal surgery.
2. Presence of a secondary or complicated hernia.
3. Incomplete medical records or missing ultrasound data.

The medical history, physical examination, and ultrasound assessments were performed by a pediatric surgeon certified in pediatric ultrasonography. The medical history focused on symptoms related to umbilical hernia, as well as any past episodes of incarceration.

During the study period, 35 patients were referred to the pediatric surgery outpatient clinic with a diagnosis of umbilical hernia. 5 patients were excluded from the analysis:

1. Two patients had prior ultrasound examinations performed in other institutions on different ultrasound devices, making the imaging data noncomparable.
2. One patient had a history of previous abdominal surgery (inguinal hernia repair).
3. One patient had a previously diagnosed umbilical hernia that had resolved spontaneously at follow-up; the patient was referred for control, but no hernia was present at the time of evaluation.
4. One patient had incomplete medical records, missing ultrasound data.

Patients with a history of previous abdominal surgery, including laparoscopic or open inguinal hernia repair, were excluded because such procedures can alter the anatomy of the abdominal wall and potentially influence the umbilical ring, which could affect the assessment of the hernial defect and confound the results.

As a result, the records of 30 children (13 girls, 17 boys) were subjected to further analysis. The age was assessed with the accuracy to one month and varied from 1 month to 4.5 years (mean: 1.32; median: 1; SD: 0.17).

Ultrasonographic evaluation of the umbilical hernia was performed with the Aloka Prosound Alpha 6 Diagnostic Ultrasound System (ALOKA Co., Ltd., Tokyo, Japan) with the linear probe. All examinations were conducted according to a predefined uniform protocol by a pediatric surgeon certified in pediatric ultrasonography. Patients were examined in the supine position at rest and measurements were taken in the transverse plane at the widest point of the umbilical ring. The width of the hernial orifice was measured with an accuracy of 0.1 mm. Each measurement was taken three times and averaged to improve accuracy. The contents of the hernial sac were evaluated and differentiated based on echogenicity, peristalsis, and Doppler signal, allowing identification of intestinal loops versus preperitoneal fat. Additional maneuvers, such as observation during mild crying, were performed when necessary to visualize the contents of the hernia.

Intraobserver variability was not formally assessed in this study; this limitation is acknowledged.

This study was a retrospective analysis of deidentified routine clinical data (analysis of existing medical records) and did not involve any intervention or influence on patient management. The study did not involve any intervention or influence on patient management. Therefore, according to national regulations and the Declaration of Helsinki, formal approval from the Bioethics Committee of the University of Opole was not required for this type of study. Patient confidentiality was strictly maintained and no identifiable personal data was used.

Statistical analysis was conducted using Excel and PAST 4.03. Descriptive statistics were used to summarize the data. Mean, standard deviation (SD), and range (minmax) were calculated for continuous variables, including the width and age. The Shapiro-Wilk test was applied to assess the normality of the distribution. Comparisons between groups were performed using the independent samples t-test for normally distributed variables and the Mann-Whitney U test for nonnormally distributed data. The relationship between age and hernial orifice width was assessed using Pearson's correlation coefficient. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. Statistical tests were selected based on sample size and data distribution characteristics. No formal correction for multiple comparisons was applied; however, only key analyzes were interpreted in the context of hypothesis testing. A p-value<0.05 was considered statistically significant.

Results

The characteristic of the study group is presented in Table 1. Children with intestinal loops in the hernia sac were younger than those with preperitoneal fat (p=0.016).

Table 1. The age of patients and other parameters

		The age of children (years)				
	n	**Mean±SD**	**Median (Q1; Q3)**	**Min**	**Max**	**p**
Total	30	1.50±1.46	1.13 (0.17; 2.06)	0.04	5.08	
Gender						
Boys	17	1.65±1.64	1.17 (0.31; 2)	0.08	5.08	0.685
Girls	13	1.30±1.15	1.08 (0.16; 2.22)	0.04	4.00	
The content of the hernial sac						
Intestine loops	12	0.90±1.24	0.17 (0.15; 1.21)	0.04	4.50	0.016
Preperitoneal	18	1.90±1.45	1.92 (0.77; 2.5)	0.17	5.08	

The medical history of the patients included in the analysis revealed that there was no episode of incarceration in the past. The symptoms related to the umbilical hernia revealed that three children had symptoms of umbilical inflammation (they were seen and examined by the pediatric surgeon within the first three months of life). One patient reported abdominal pain. which was more associated with lactose intolerance than umbilical hernia. In another case. Parents noticed a significantly more frequent protrusion of the umbilical hernia since the child began experiencing constipation. One patient suffered emotionally due to peers at school who mocked the appearance of his navel.

Only 6.67% (2 children) were qualified for surgical treatment. The hernial orifice width in these patients was 20 mm (20 mm and 23.8 mm). According to expert recommendations in asymptomatic cases, surgical

treatment is considered after the age of 3 years. In the study group, surgical treatment was considered in a small proportion of patients. The indications for surgery were based on symptoms (frequent protrusion) and significant cosmetic deformity leading to psychosocial discomfort, particularly problems reported by school-aged children during peer interactions or physical activities.

Analysis of ultrasound measurements of the width of the hernial orifice width revealed that the umbilical orifice was wider in boys than in girls (mean±SD: 15.44±1.64 mm vs. 13.08±2.43 mm; p=0.043) (Table 2, Fig. 1). Neither ultrasonographic hernial sac contents nor age differed significantly between boys and girls (Table 1). Given the small sample size, the clinical relevance of the difference in the width of the hernial orifice between sexes should be interpreted with caution.

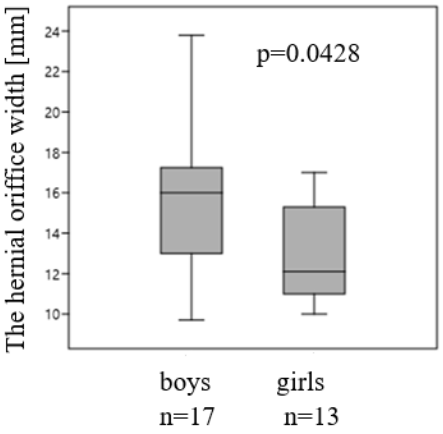

Fig. 1. The width of the hernial sac in boys and girls. In the box plot. The line inside the box represents the median. The box shows the SD and the whiskers indicate the standard error of the mean (SE), the umbilical orifice was wider in boys than in girls (mean±SD: 15.44±1.64mm vs. 13.08±2.43mm)

Table 2. Ultrasonographic evaluation of the hernial sac width in children and other parameters

	The hernial orifice width in children					
	n	**Mean±SD**	**Median (Q1; Q3)**	**Min**	**Max**	**p**
Total	30	14.42±3.25	14.65 (11.25; 16.58)	9.70	23.80	
Gender						
Boys	17	15.44±3.43	16.00 (13.5; 17)	9.70	23.80	0.043
Girls	13	13.08±2.43	12.10 (11.0; 15.15)	10.00	17.00	
Age						
<1 year old	13	14.72±2.55	15.60 (13.0; 17.0)	10.70	17.80	0.508
≥1 year old	17	14.18±3.68	14.20 (11.0; 15.0)	9.70	23.80	

The content of the hernial sac						
Intestine loops	12	16.06±3.10	16.45 (14.8; 17)	10.70	23.80	0.028
Preperitoneal fat	18	13.32±2.87	13.00 (11.0; 15.68)	9.70	20.00	

No significant differences in hernial orifice width were found between children under and over 1 year of age, and no meaningful correlation with age was observed (Pearson correlation coefficient r=0.16, p=0.397, Table 2, Fig. 2).

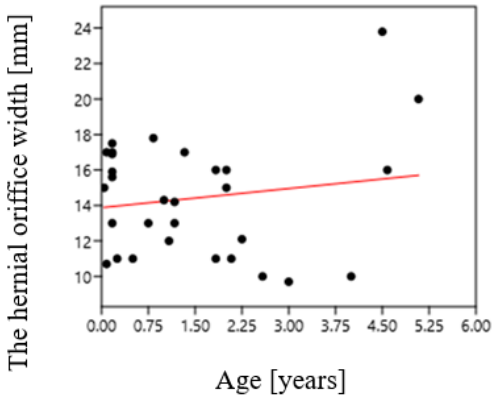

Fig. 2. The correlation between age and the width of the hernial orifice measurement

The hernial sac contained intestinal loops (n=12) and preperitoneal fat (n=18). Blood flow on color Doppler and reducibility was confirmed in all patients, and peristalsis was observed when intestinal loops were present. Patients with intestinal loops in the hernial sac were significantly younger (p=0.016; Table 1) and had a wider hernial orifice (p=0.028; Table 2; Fig. 3). Among children with an orifice >14 mm (n=17), intestinal loops were more frequent than in those with <14 mm (58.8% vs. 15.4%; p=0.026; Fig. 4).

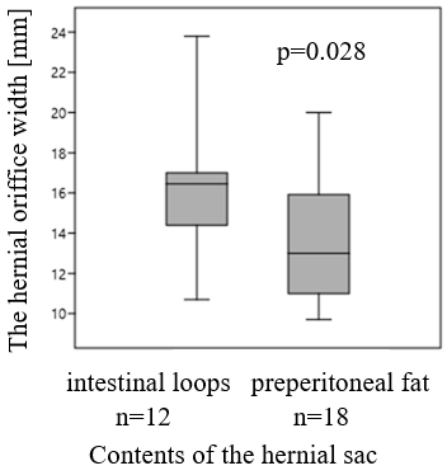

Fig. 3. The width of the hernial sac in children and contents of the hernial sac. In the box plot. The line inside the box represents the median. the box shows the standard deviation (SD) and the whiskers indicate the standard error of the mean (SE)

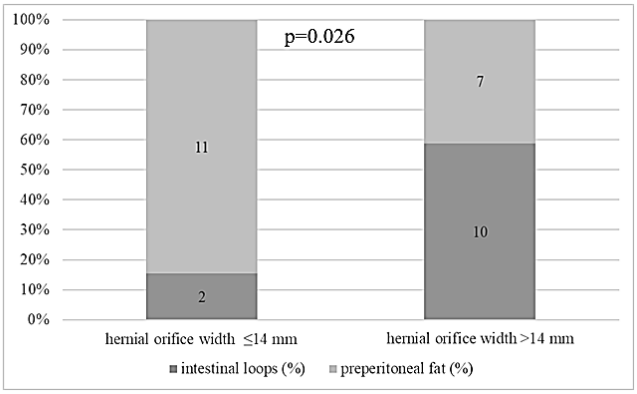

Fig. 4. The width of the hernial sac in children and contents of the hernial sac

Discussion

Although umbilical hernias are a common disease in the pediatric population. The number of studies that specifically analyze the relationship between patient age. hernial orifice width. hernial sac content. and sex remains limited. Most of the available literature focuses on the natural history, indications for surgery, and the timing of the intervention. However. detailed ultrasonographic assessments of hernia morphology and contents are relatively rare. and there is a lack of standardized criteria to guide clinical decision-making based on imaging findings. Furthermore. Comparative data that correlating ultrasonographic characteristics with patient demographics are few. This highlights the need for more structured research to better understand the anatomical and clinical factors that may influence the treatment of pediatric umbilical hernias.

The present study provides one of the few standardized ultrasound analyzes of primary pediatric umbilical hernias that correlates the width of the hernial orifice with sac contents, age, and sex. By focusing on these objective measurements, the study confirms some previously reported trends (such as a wider inter-rectus distance in boys) and introduces novel observations, including the exploratory cut-off of 14 mm for predicting intestinal loop presence in the sac. These contributions distinguish the study from prior work that relied solely on clinical assessment or nonstandardized measurements.

It should also be emphasized that ultrasonographic examination is not necessary for the diagnosis of umbilical hernia. as clinical evaluation is usually sufficient. However, Serial measurements of the hernial orifice width may be useful for monitoring the dynamics of defect closure over time. The rate of change in orifice width or its stagnation – may support clinical decision-making regarding the timing of surgical intervention.

Although umbilical hernia is a common condition in children. There remains a significant knowledge gap regarding its epidemiology and defect size. There is a lack of reliable, patient-based studies in which hernia measurements are standardized and comparable across cases.

Yanagisawa et al. examined umbilical hernia closure by ultrasonography in 97 infants (52 boys, 45 girls) and reassessed the benefits of adhesive strapping.[5] Interestingly. The authors defined the closure speed (CS) as the reduction in the diameter of the hernia per week. It was calculated by dividing the diameter of the hernia orifice before treatment by the duration of treatment (weeks).[5] The children included in the study were divided into two age groups: under 12 weeks and between 12 and 26 weeks of age. The authors did not analyze the size of the hernial orifice considering the patients' age or gender of the patients. However, at the beginning of the study. the hernial orifice measured 11.6 mm (range 8–15 mm) in the observation group and 11.8 mm (range 5–26.3 mm) in the adhesive strapping group.[4] It was smaller than in the study group of this research and can be associated with the younger age of the patients included in the study by Yanagisawa et al.

Nakajima et al. measured the width of the linea alba in 30 pediatric patients (14 boys. 16 girls) with umbilical hernias.[6] Since the linea alba does not exist at the level of the umbilicus in patients with pediatric umbilical hernias. they reported the median transverse diameter of the hernia defect as 13 mm. The ages ranged from 2 to 7 years (mean age for children with hernias: 3.8±1.3 years).[6]

Kaur et al. performed a retrospective chart review of 2621 patients (51% were girls) referred for umbilical hernia and the median size of the defect was 7 mm (5.0 to 10.0). However, the authors did not report the technique of hernial orifice measurement and admit that there were considerable missing data for the size of the defect in 1257 participants.[7]

Our results show that the hernial orifice was wider in boys than in girls. This may reflect anatomical and biomechanical differences in the development of the abdominal wall between sexes during infancy and infancy. A wider orifice in boys may also predispose to a more frequent intestinal content in the hernial sac,

as observed in younger patients with larger defect diameters. These observations are consistent with previous studies in healthy children indicating that in boys without umbilical hernia in supine position the interrectus distance at the level of umbilicus is greater than in girls.[8] This difference may be related to variations in abdominal wall muscle development, connective tissue strength. Although the underlying mechanism requires further investigation, our data suggest that sex and age are important factors that influence the morphology of pediatric umbilical hernias.

Litz et al. conducted a randomized clinical trial on percutaneous ultrasound-guided versus intraoperative rectus sheath block for 58 pediatric umbilical hernia repair and in their study group 57% were women.9 The age of participants varied from 3.2 to 17.2 years and the authors did not distinguish between primary and secondary hernia.[9] Male preponderance of 63% was reported by Ngom et al. reported a preponderance of men of 63% (umbilical hernia in 2146 pediatric cases).[10]

Tonosaki et al. analyzed 77 cases of umbilical hernias (41 boys and 36 girls). Mean age 52.7±18.3 days) treated with the tape fixation method and classified the hernia size according to the height of the bulge: mild (<1 cm). moderate (1 and <3 cm) or severe (>3 cm).[11] They did not find significant differences in sex or age at the beginning of treatment between sizes.[11]

Compared to these previous studies, the present findings extend knowledge by explicitly correlating the width of the hernial orifice with sac content and demographic factors. While previous reports often lack standardized measurements, distinction between primary and secondary hernias, or complete demographic correlations, our results demonstrate clear associations: larger defects are more likely to contain intestinal loops, and younger children are affected more frequently.

The reviewed literature does not clearly distinguish between primary and secondary umbilical hernias. Although it can be assumed that the majority of pediatric cases are congenital, it can be assumed that the majority of pediatric cases are congenital. For the sake of clarity and consistency, such classification should be explicitly addressed. Moreover, many studies lack a standardized method to measure hernial defect. which limits the comparability of findings.

This study has several limitations inherent to its retrospective design. First, the analysis was based on medical records of pediatric patients with umbilical hernia who came to the pediatric surgery outpatient clinic and only patients referred for elective outpatient evaluation were included. It is likely that symptomatic cases or those with complications presented directly to the emergency department and therefore were not captured in this analysis. This may have resulted in selection bias and an underrepresentation of more serious symptomatic clinical presentations. Furthermore, patients with ultrasound examinations performed in other institutions were excluded, which may further limit the representativeness of the study cohort.

Second, the study was carried out in a single center, which may reduce the generalizability of the findings to other populations with different demographics or clinical practices. Third, the sample size was relatively

small, which limits statistical power and the ability to detect subtle differences between subgroups. Furthermore, multiple statistical comparisons increase the risk of type I error, and therefore the results should be interpreted with caution.

Fourth, due to the retrospective nature and the relatively short study period, no follow-up data were available to assess the natural progression or regression of umbilical hernias over time. Furthermore, some clinical information, such as parental reports of hernia symptoms, was not systematically recorded, as the study mainly focused on objective ultrasonographic measurements.

Despite these limitations, the study has several strengths. All ultrasounds were performed by a single experienced pediatric surgeon, ensuring consistency in measurement technique and minimizing variability between observers. The focus on objective and measurable variables hernial orifice width and sac contents – allowed identification of associations that may be clinically relevant. The exploratory cut-off point of 14 mm for the presence of the intestinal loop, while hypothesis-generating, could inform future follow-up protocols and risk stratification. These results highlight ultrasonography as a valuable monitoring and documentation tool, particularly in cases where the timing of surgical intervention or defect dynamics is uncertain.

Conclusion

The analysis of ultrasonographic measurements indicated that the hernial orifice was generally wider in boys than in girls. Younger children were more likely to have intestinal loops in the hernial sac. Patients with intestinal loops present during ultrasonographic examination tended to have a larger hernial orifice, with loops observed more frequently when the orifice exceeded 14 mm.

These findings suggest that the ultrasound evaluation of pediatric umbilical hernias – particularly the evaluation of the width of the orifice and sac content – may provide useful additional information to support clinical evaluation and follow-up, although the results should be interpreted cautiously due to the retrospective design and limited sample size.

Declarations

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Author contributions

Conceptualization. A.K.-R.; Methodology. A.K.-R.; Software. A.K.-R.; Validation. A.K.-R.; Formal Analysis. A.K.-R.; Investigation. A.K.-R.; Resources. A.K.-R.; Data Curation. A.K.-R.; Writing – Original

Draft Preparation. A.K.-R.; Writing – Review & Editing. A.K.-R.; Visualization. A.K.-R.; Supervision. A.K.-R.; Project Administration. A.K.-R.; Funding Acquisition. not applicable.

Conflicts of interest

The author declares no competing interests.

Data availability

The data sets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval

This study is a retrospective analysis of deidentified routine clinical data. According to national regulations and the Declaration of Helsinki, formal approval was not required from the Bioethics Committee of the University of Opole for this type of study. Patient confidentiality was strictly maintained and no identifiable personal data was used.

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