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# Structure of direct and indirect umbilical hernia and the implication on surgical repair in children



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## Abstract

**Background:** Umbilical hernia (UH) is one of the most common problems seen by paediatric surgeons. The recurrence rate after surgical repair is 1–2%. In this study, we examined the ring of umbilical hernia histologically to detect differences between the two types of umbilical hernia and the relation between this histologic difference and the technique of surgical repair.

**Results:** Fifty paediatric patients of both sexes with clinically diagnosed direct and indirect (oblique) umbilical hernia were collected from the paediatric surgery department in the period between March 2016 and February 2018. Age ranged between 2 and 5 years. Biopsies (5 mm) were taken from the upper, lower, right and left borders of the ring in both types and processed for histological examination. Classification of umbilical hernia was based on Chang-Seok et al.'s classification, which classified the umbilical hernia into three types (direct, oblique and hernia into umbilical cord) which depend on the presence of a hole in the ring and whether the ring is covered by ligamentum teres or not. Histological sections were examined by light microscopy, and data was analysed using chi-square test to detect predominance of one type of collagen fibre over the other in each sample. Transverse collagen fibres were predominant in the upper border of the ring in 15 patients (75%) and the lower border in 14 patients (70%) of direct umbilical hernia. Transverse collagen fibres were also predominant in the right border of the ring in 21 patients (70%) and the left border in 21 patients (70%) of indirect umbilical hernia. This predominance in both cases was found to be statistically significant.

**Conclusions:** Predominance of transverse collagen fibres in the upper and lower borders of the ring in direct umbilical hernia and predominance in the right and left borders of the ring in oblique umbilical hernia encouraged us to suggest that wound will be more stable if closed in a transverse manner in direct umbilical hernia and a longitudinal manner in oblique umbilical hernia especially in recurrent cases.

**Keywords:** Direct hernia, Indirect hernia, Transverse fibres, Umbilical hernia, Collagen fibres

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## Background

Umbilical hernia (UH) is one of the most common problems seen by paediatric surgeons. The true incidence of umbilical hernia is unknown because most umbilical hernias resolve spontaneously. Race and prematurity are predisposing factors with umbilical hernias found more commonly in children of African descent. The incidence of umbilical hernias decreases with advancing age. There was a high familial incidence, but no genetic pattern of inheritance had been identified. Umbilical hernia was found to be commonly associated with a number of congenital malformations including thyroid dysgenesis, trisomy 13, trisomy 18, trisomy 21 and Beckwith-Wiedemann syndrome [1].

Umbilical hernia results from incomplete closure of the umbilical ring. The umbilical ring represents a defect in the linea alba. The linea alba with the rectus sheaths is the collagenous part of the anterior abdominal wall. The collagen fibres in the linea alba are arranged in transverse and oblique manners. The transverse fibres play a major role in resisting intraabdominal pressure and the oblique fibres are responsible for movement [2, 3]. Two types of congenital UH were identified, the direct type which occurs as a result of weakening or absence of the supporting fascia of the umbilical defect. The other type was the indirect (oblique) type where the peritoneal contents herniated from a point immediately superior to the umbilical ring [4, 5].

The standard technique for repair of umbilical hernia in children includes closure of the circular defect in the linea alba and the peritoneum (the umbilical ring) in a transverse manner regardless of the type of umbilical hernia [6]. The recurrence rate of umbilical hernia after repair is quite variant in the literature and increases with the period of follow-up [7]. The recurrence rate ranges between 1 and 2% in most of the literature and no significant difference between the direct and indirect type of umbilical hernia [8–10].

Recurrence was attributed to many factors like suture type, technical failure or associated co-morbidities. Using non-absorbable sutures like silk had 6 times higher recurrence than absorbable sutures due to increased tissue reactivity [10]. Presence of at least one comorbidity like

cardiopulmonary, neuro-degenerative, biliary, musculoskeletal or chromosomal diseases increases the recurrence rate [10]. In this study, we examined the ring of umbilical hernia histologically to detect differences between the two types of umbilical hernia and the relation between this histologic difference and the technique of surgical repair.

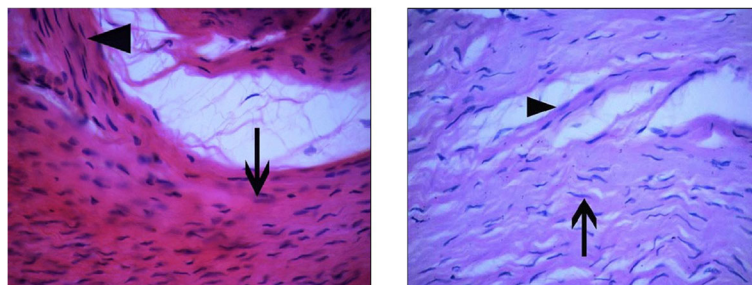
## Methods

It was a prospective cohort study which was carried out on fifty patients of both sexes (20 males and 30 females) with a clinically diagnosed umbilical hernia (direct and indirect types) to study the histological structure of the ring of umbilical hernia as regard the arrangement of the collagen fibres in both types of the UH and to modify the technique of the surgical repair accordingly. The selected cases were collected from the paediatric surgery department during the period between March 2016 and February 2018; the patients' age ranged from 2 to 5 years old. Patients with recurrent umbilical hernia, those with fascial defect greater than 5 cm and those with genetic syndromes, were excluded from the study. All biopsies were obtained with informed consent as approved by our university human research ethics committee.

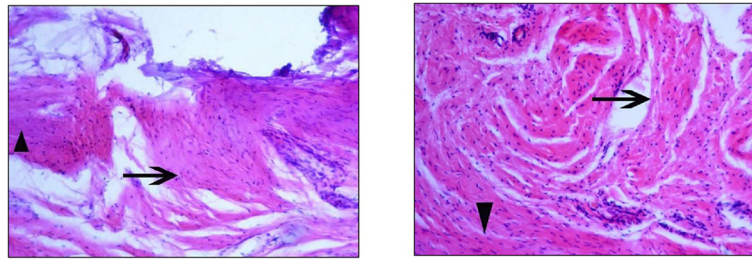
All patients were subjected to preoperative evaluation through clinical examination. The hernia was examined carefully to determine if the defect was superior to the umbilicus (indirect type) or it was directly behind the umbilicus (direct type).

Hernia was classified as direct and indirect (oblique) using Changseok et al.'s classification, which classified the umbilical hernia into three types based on the presence of the hole in the ring and whether the ring is covered by ligamentum teres hepatis or not. Direct hernia was identified when the hernia points through the umbilical orifice and considered the most common types occurring in infants. Indirect (oblique) type was identified when the bowel or hernia contents press down the umbilicus and present at the upper border of the umbilicus. This type occurs later in infancy and likely to persist [4, 5].

Biopsy (5 mm) was taken from the ring during repair of the UH at the stage of excision of the sac. Four



**Fig. 1** Predominance of the transverse collagen fibres in the upper and lower borders of the ring of the direct umbilical hernia (the arrow points to the transverse fibres while the arrowhead points to the oblique fibres)



**Fig. 2** Predominance of the oblique fibres in the right and left borders of the ring of the direct umbilical hernia (the arrow points to the oblique fibres while the arrowhead points to the transverse fibres)

biopsies were taken from the upper, lower, right and left edges of the ring. Specimens were fixed in 10% formalin, dehydrated and cleared. Paraffin sections were prepared and subjected to haematoxylin and eosin (H&E) stain. Stained sections were examined by light microscope to determine the predominance of one type of collagen fibres (transverse which is involved in strength and stability or oblique which is involved in the movement of the anterior abdominal wall) over the other in the four specimens of every patient. All defects were closed in transverse fashion as per our standard technique because we did not want to change the technique till we have a clear data to justify that.

## Results

Fifty patients (20 males and 30 females) presented with umbilical hernia (direct and indirect) to the paediatric surgery department. Their age ranged between 2 and 5 years old. Twenty-nine patients had the direct type and 21 patients had the indirect type of umbilical hernia. Four (5 mm) biopsies were taken from each corner of the umbilical defect during the repair and were sent for histology to detect the transverse collagen fibres.

Haematoxylin and eosin (H&E)-stained sections showed that transverse collagen fibres were more predominant than oblique collagen fibres in the upper (75% of cases) and lower (70% of cases) borders (Fig. 1) and less predominant in the right (40% of cases) and left (30% of cases) borders (Fig. 2) of the ring in the direct type of umbilical hernia (Table 1). The predominant collagen fibres were counted using light microscopy by an experienced histologist.

**Table 1** Comparison between the four borders of the ring of the direct umbilical hernia as regard the predominance of the transverse collagen fibres (number of cases)

Border	Transverse collagen fibres
Upper	15 (75%)
Lower	14 (70%)
Right	8 (40%)
Left	6 (30%)

The predominance of the transverse collagen fibres in the upper and lower borders of the ring of direct umbilical hernia was significantly higher compared to the right and left borders, which was statistically significant ( $p$  value < 0.05).

On the other hand, H&E-stained sections showed that transverse collagen fibres were more predominant in the right and left borders (70%) (Fig. 3) and less predominant in the upper (36%) and lower (26%) borders (Fig. 4) of the ring in the indirect type of umbilical hernia (Table 2).

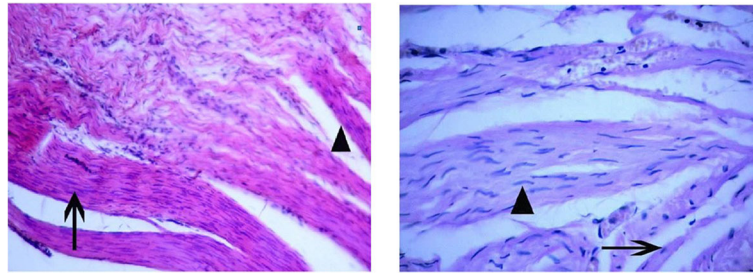
The predominance of the transverse collagen fibres in the right and left borders of the ring of indirect umbilical hernia was significantly higher compared to the upper and lower borders, which was statistically significant ( $p$  value < 0.05).

## Discussion

The anatomy of the anterior abdominal wall has consistently been of interest to anatomists over decades. It played a significant role in surgery. In addition, the abdominal wall was considered an important way in opening the peritoneum where it is involved in hernia sac formation. Therefore, the anterior abdominal wall is the object of different surgical investigations regarding wound healing and wound closure [2].

One of the commonest problems faced by the paediatric surgeons is the umbilical hernia. The recurrence rate of umbilical hernia was reported to be around 10–15% [7]. The traditional repair of the umbilical hernia included transverse closure of the fascial defect in the linea alba [6]. This technique is being used for both types of umbilical hernia without taking into consideration the structural difference between the two types. Most of the literature studies are discussing the difference between interrupted and continuous closure or repair with and without a mesh [11].

In El Den et al.'s study, there was no difference between continuous and interrupted closure of umbilical defect [12]. We could not spot any study in the literature about the histological difference of the umbilical defect and the implication on repair.



**Fig. 3** Predominance of the transverse collagen fibres in the right and left borders of the ring of the indirect umbilical hernia (the arrow points to transverse fibres while the arrowhead points to the oblique fibres)

Conze et al. in 2005 attributed the high recurrence rate of incisional hernia (40%) to the direction of the suture line in relation to the transverse collagen fibres in the linea alba. This assumption opened the way to think about the role of the transverse collagen fibres in the linea alba in wound healing [13].

Axer and his colleagues in 2001 demonstrated that the lamina fibrae transversae (the transverse fibres in the linea alba) may be of significance in the choice of direction of laparotomy incision. They added that transverse laparotomy incisions are more resistant to rupture than longitudinal incisions. In fact, in transverse laparotomy, the transverse fibres in linea alba and rectus sheaths are not cut and can serve their function, while in longitudinal incisions, the sutures are not fixed in between the cut transverse fibres [2].

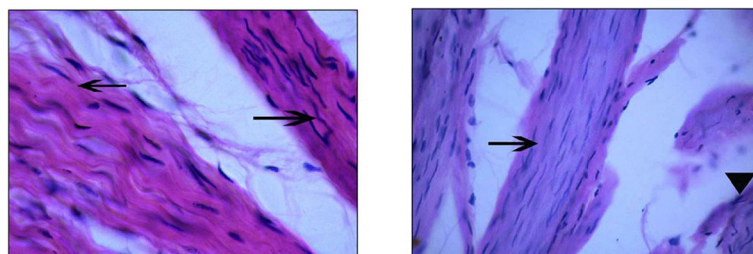
In this study, the histological structure of the umbilical ring in both types of umbilical hernia was studied to detect the difference in the structure between the two types and to modify the technique of surgical repair according to the arrangement of the collagen fibres to give more strength to the repair by repairing mainly the transverse collagen fibres in the linea alba. The patients in our study underwent surgical repair of their umbilical hernia by the traditional method (the transverse closure of the fascial defect in both types of the hernia), and before closure, a biopsy from the upper, lower, right and left corners of the umbilical ring was taken. The biopsies were preserved in 10% formalin and paraffin sections

were done after drying and cleaning of the specimens. The specimens were stained with haematoxylin and eosin and examined under the light microscope.

Collagen was found to be the predominant protein in the abdominal fascial layers and accounts for 80% of the structural tissue. Two types of collagen fibres were found in the architecture of linea alba, transverse fibres which are responsible for counteracting intrabdominal pressure and oblique fibres which are involved mainly in the movement. Reduction in wound transverse collagen level decreases the wound tensile strength and increases the risk of mechanical wound failure and may lead to wound dehiscence [2].

We found that the arrangement of the collagen fibres in the four corners of the ring of umbilical hernia differed significantly in both types of the hernia. In the direct type, the transverse collagen fibres were significantly more predominant in the upper and the lower borders of the ring. Therefore, closure will be more stable if it is performed in a transverse manner (the upper and lower borders come in apposition). In the indirect type, the transverse collagen fibres were significantly more predominant in the right and left borders of the ring. So, the closure will be more stable if it is performed in a longitudinal manner (the right and left borders come in apposition).

We have no sufficient data to determine if this structural difference has in practice surgical implication or not, but this can be very helpful to be applied in



**Fig. 4** Predominance of the oblique fibres in the upper and lower borders of the ring of the indirect umbilical hernia (the arrow points to the oblique fibres while the arrowhead points to the transverse fibres)



**Table 2** Comparison between the four borders of the ring of the indirect umbilical hernia as regard the predominance of the transverse collagen fibres (number of cases)

Borders	Transverse collagen fibres
Upper	11 (36%)
Lower	8 (26%)
Right	21 (70%)
Left	21 (70%)

recurrent cases to decrease the incidence of dehiscence. Further studies using electron microscopy to detect the amount of collagen in the four corners of the umbilical ring might be very helpful to confirm or reject our hypothesis. Considering other factors that might lead to recurrence like comorbidities, type of sutures and size of umbilical hernia should be considered before applying any changes to the standard way of umbilical hernia closure.

There are some other factors that may affect healing and increases the recurrence rate like age and sex of the patients, but previous studies in the literature showed no significant effect on recurrence rate [13, 14].

## Conclusion

We recommend that fascial defect should be closed transversely in the direct type of UH and to be closed longitudinally in the indirect type based on the histologic difference found to make the closure more stable especially in recurrent cases. However, further studies and follow-up of the patients are to be done to demonstrate the results of the surgical application of this histological difference.

## Abbreviations

UH: Umbilical hernia; H&E: Haematoxylin and eosin

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Not applicable

## Authors' contributions

MM, ME and HE shared in writing, collecting and analysing the data. MA was responsible for histology specimen and writing all histology reports. All authors have read and approved the final manuscript.

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No funding was needed.

## Availability of data and materials

The data and material is available for review.

## Ethics approval and consent to participate

This study was approved by the IRB of the surgery department, faculty of medicine, with the reference number 00006379. A written consent was obtained from a parent or guardian for participants under 16 years old. A written consent was obtained directly from patients if they were over 16 years old.

## Consent for publication

I give my consent and all authors consent for publication in the Annals of paediatric surgery journal.

## Competing interests

There was no conflict of interest in this project.

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