The First Application of Intraumbilical Longitudinal Incision to Pyloromyotomy for Hypertrophic Pyloric Stenosis

Keisuke SUZUKI, Makoto KOMURA, Ryosuke SATAKE, Kan TERAWAKI, Tetsuro KODAKA, Takumi GOHARA and Hironobu YONEKAWA

Department of Pediatric Surgery, Saitama Medical University

(Received January 4, 2023; Accepted April 12, 2023)

Objective: There are several approaches to pyloromyotomy for the treatment of hypertrophic pyloric stenosis including open transumbilical pyloromyotomy and laparoscopic pyloromyotomy. Beginning in 2012, we adopted intraumbilical longitudinal incision as a new transumbilical approach for pyloromyotomy. We describe details of the operative technique and results of this new approach.
Methods: We reviewed records of patients undergoing transumbilical pyloromyotomy from 2005 to 2018. Perioperative outcomes were compared between intraumbilical longitudinal incision and supraumbilical incision, the latter of which is the conventional incision for transumbilical pyloromyotomy.
Results: Twenty-four patients underwent pyloromyotomy with intraumbilical longitudinal incision (intraumbilical group) and 28 patients with supraumbilical incision (supraumbilical group). The median operative time was longer in the intraumbilical group (58.0 vs. 43.5 min, p = 0.002). However, the time to full feeding did not differ significantly between the two groups, and the median postoperative stay was shorter in the intraumbilical group (3 vs. 5.5 days, p = 0.003). There was no difference in the rate of complications (4.2% vs. 7.1%, p = 1.0). Scars after intraumbilical longitudinal incision were localized inside the umbilicus.
Conclusion: Pyloromyotomy can be performed through intraumbilical longitudinal incision as safely as supraumbilical incision and intraumbilical longitudinal incision may improve cosmetic results. This approach can be an alternative technique for pyloromyotomy.

Key words: hypertrophic pyloric stenosis, pyloromyotomy, transumbilical, complication

INTRODUCTION

Hypertrophic pyloric stenosis refers to the idiopathic thickening of gastric pyloric musculature which leads to gastric outlet obstruction. The pyloromyotomy procedure for the treatment of hypertrophic pyloric stenosis described by Ramstedt in 1912 has proven to be effective [1]. This original procedure was performed through a right upper quadrant transverse incision. Since then, several other approaches to pyloromyotomy were reported, including open transumbilical pyloromyotomy [2] and laparoscopic pyloromyotomy [3].

Laparoscopic pyloromyotomy has gradually become the major approach to treat hypertrophic pyloric stenosis. Meta-analysis of randomized controlled studies revealed that laparoscopic pyloromyotomy was associated with a shorter time to full feeds, but with a slightly higher rate of incomplete myotomy compared with open pyloromyotomy [4]. Some retrospective studies also noted higher rates of incomplete myotomy [5] and bowel injury [6] with laparoscopic pyloromyotomy in comparison with the open approach. Therefore, the degree of skill should be considered for the choice of laparoscopic surgery.

Among the transumbilical approaches, supraumbilical incision was first described by Tan and Bianchi in 1986 [2]. Since then, various incisions applied in transumbilical approaches were reported such as supraumbilical incisions [6–8], right semicircular umbilical incision [9], and infraumbilical incision [10]. One of the advantages of transumbilical approaches is good postoperative cosmetic results [7, 9, 10]. At the same time, several studies reported that supraumbilical incision did not increase perioperative complications compared with the traditional transverse incision [7, 8] and the laparoscopic approach [6–8].

As a new transumbilical approach for pyloromyotomy, beginning in 2012 we adopted intraumbilical longitudinal incision aiming at further improvement in cosmetic results of the transumbilical approach. We speculated that intraumbilical longitudinal incision may offer a better cosmetic result than supraumbilical incision because the intraumbilical longitudinal incision is straight, is inside the umbilical crease and would be masked by its fold. In contrast, a supraumbilical incision, which is the most common incision for transumbilical pyloromyotomy, is curved and outside the umbilicus, and tends to leave obvious scars or umbilical deformity. Furthermore, we assumed that the cosmetic outcome of intraumbilical longitudinal incisions is equivalent with that of the laparoscopic approach because our approach does not require extra incisions outside the umbilicus.

The purpose of this study is to confirm whether

Makoto KOMURA, Department of Pediatric Surgery, Saitama Medical University, 38 Morohongo, Moroyama-cho, Irumagun, Saitama 350-0495, Japan
Tel: +81-49-276-2116 Fax: +81-49-276-1825 E-mail: komura-tky@g.ecc.u-tokyo.ac.jp

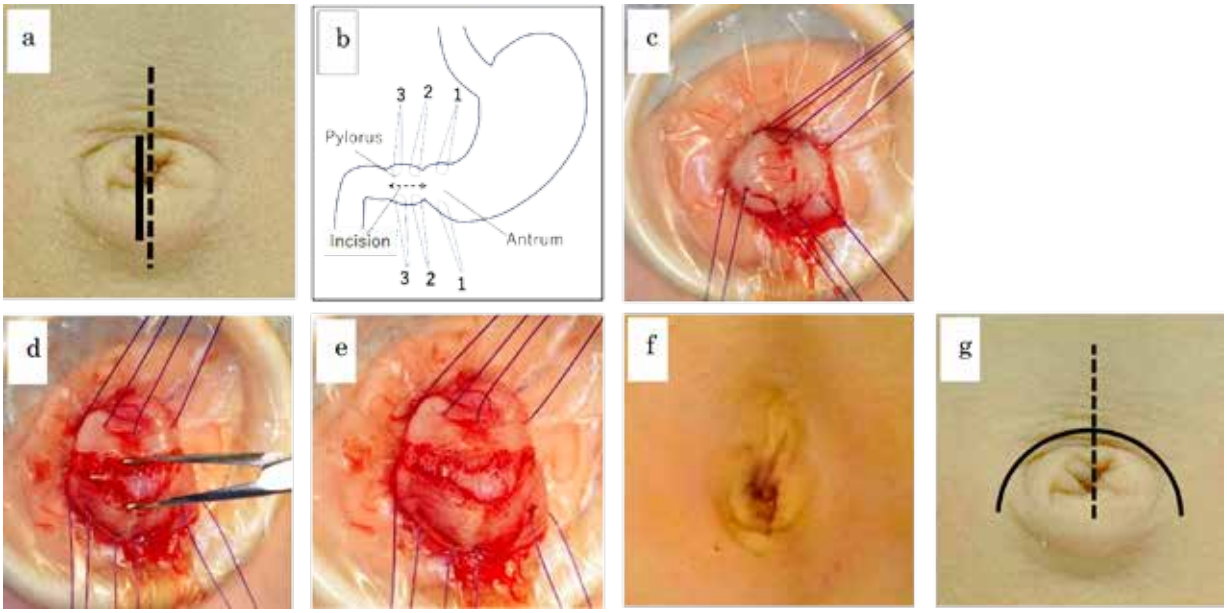

Fig. 1 (a-g) Surgical procedure of pyloromyotomy with an intraumbilical longitudinal incision
a. Incision of the skin and fascia: A longitudinal skin incision is made inside the umbilical crease (continuous line —). The abdominal cavity is opened and incision of the linea alba is performed (dotted line---). The incision of the linea alba is longer than the skin incision.
b. Illustration of stay sutures placed on the stomach: First, two stay sutures (Sutures 1) (3-0 absorbable sutures) are placed on the wall of the antrum of the stomach. The ends of Suture 1 are labeled as "1" in the figure, the ends of Suture 2 are labeled as "2" in the figure, and so on. After the stay sutures on the antrum are retracted, the pylorus is brought into the wound. Additional stay sutures (Sutures 2, 3) are placed on the wall of the pylorus.
c. By retracting the stay sutures on the pylorus, the pylorus can be held in position in the wound.
d. The anterior surface of the pylorus is incised, and myotomy is performed by a pyloric spreader.
e. Pylorus after myotomy.
f. The fascia and skin have been closed. The umbilical stump is usually not attached to the fascia.
g. Diagram showing incisions of the skin (continuous line —) and linea alba (dotted line---) during pyloromyotomy with a supraumbilical incision.

pyloromyotomy for hypertrophic pyloric stenosis can be performed through an intraumbilical longitudinal incision as safely as through a supraumbilical incision. In this paper, we present details of this operative technique and compare the outcomes of intraumbilical longitudinal incision with the outcomes of supraumbilical incision for pyloromyotomy.

MATERIALS AND METHODS

This study was performed in accordance with the ethical policy of Saitama Medical University and the principles of the Declaration of Helsinki of 1964. We retrospectively reviewed the records of all patients who underwent pyloromyotomy for hypertrophic pyloric stenosis at the Hospital of Saitama Medical University between April 2005 and February 2018. In the Department of Surgery at the Hospital of Saitama Medical University, there was a change in the pediatric surgery team in 2012, in which new pediatric surgeons were appointed in the Department of Pediatric Surgery in July 2012. The new pediatric surgery team developed the procedure of pyloromyotomy through an intraumbilical longitudinal incision as an alternative to pyloromyotomy through a supraumbilical incision in July 2012. All pyloromyotomy surgeries for the treatment of hypertrophic pyloric stenosis have been performed through an intraumbilical longitudinal incision since July 2012 at our hospital.

Patients and data collection

Demographic data and operative outcomes were obtained from medical records. Demographic data included age, sex, admission weight, duration of symptoms, pyloric muscle thickness and pyloric muscle length.

Operative outcomes included operative time, time to full feeding, length of the postoperative stay, and incidence of perioperative complications. Perioperative complications were classified as mucosal perforation, incomplete pyloromyotomy and wound complications (infection, dehiscence, and incisional hernia) [11]. The cosmetic results were evaluated by reviewing pictures of the umbilical scar that had been taken postoperatively.

Preoperative ultrasonographic examination

Starting in July 2012, in patients who were suspected of having hypertrophic pyloric stenosis, a pediatric surgeon went to the ultrasonography room and made the ultrasonographic diagnosis of hypertrophic pyloric stenosis on behalf of the clinical technologist of ultrasonography. Diagnosis of hypertrophic pyloric stenosis was made by measuring pyloric muscle thickness and pyloric muscle length on ultrasonographic images.

Surgical procedure

A longitudinal intraumbilical incision is made inside the umbilical crease. The abdominal cavity is opened

Table 1 Characteristics of the patients who underwent pyloromyotomy

	Intraumbilical longitudinal incision n = 24	Supraumbilical incision n = 28	p value*
Age (days)	39.5 (21–98)	41 (16–78)	0.76
Sex ratio (M:F)	2:22	4:24	0.55
Body weight (g)	3452 (2405–5600)	3675 (2528–5305)	0.34
Muscle thickness** (mm)	5.2 (4.0–7.3)	5.2 (4.0–7.2)	0.39
Muscle length*** (mm)	17 (15–33)	20 (15–32)	0.035
Duration of symptoms (days)	8.5 (3–28)	9 (2–39)	0.33

Data are shown as median (range) or number.
*Statistical analysis was performed by the Fisher's exact test and the Wilcoxon rank sum test.
**Thickness of the pylorus as measured on ultrasonographic images
***Length of the pylorus as measured on ultrasonographic images

Table 2 Operative and perioperative results

	Intraumbilical longitudinal incision n = 24	Supraumbilical incision n = 28	p value*
Operative time (min)	58 (41–129)	43.5 (2–77)	0.002
Postoperative length of stay (days)	3 (2–11)	5.5 (2–31)	0.003
Time to full feeding (days)	2 (2–6)	3 (1–6)	0.06
Number (%) of patients with complications	1 (4.2%)**	2 (7.1%)***	1.0

Data are shown as median (range).
*Statistical analysis was performed by Fisher's exact test and Wilcoxon rank sum test.
**One patient developed wound dehiscence.
***One patient developed wound dehiscence, and one patient developed surgical site infection.

just under the umbilicus by a vertical fascial incision through the linea alba. The linea alba is incised vertically both cranially and caudally from the umbilicus, with the cranial incision longer than the caudal incision (Fig. 1a). Stay sutures (3–0 absorbable sutures) are placed on the wall of the antrum of the stomach. After retracting the stay sutures on the stomach, the pylorus is brought into the wound. Additional stay sutures are placed on the wall of the pylorus, and the pylorus is held in position in the wound by retracting the stay sutures (Fig. 1b, c). Intracorporeal pyloromyotomy is usually performed because it is difficult to pull the mass outside the abdomen due to the mismatch in size between the pylorus and umbilicus. While retracting the stay sutures on the pylorus, the anterior surface of the pylorus is incised, and myotomy is performed by a pyloric spreader (Fig. 1d, e). After myotomy, the stay sutures on the stomach are removed and the pylorus is placed back in its original position. The fascia and the skin are closed. Usually, the umbilical stump is not attached to the fascia (Fig. 1f).

In patients who underwent pyloromyotomy with a supraumbilical incision, a supraumbilical incision was made curvilinearly along the upper fold of the umbilicus. The abdominal cavity was opened just under the incision through the linea alba (Fig. 1g). Stay sutures were placed on the wall of the stomach only if the pylorus could not be identified or if the pylorus could not be pulled out extracorporeally through the incision. The rest of the procedure was done in the same manner as pyloromyotomy with an intraumbilical longitudinal incision.

Postoperative care

Oral feeding of 20 ml of regular formula was started 6 h postoperatively. Feedings were given every 3 h, and the amount was progressively increased. Administration of prophylactic antibiotics was normally continued for two days after the surgery. Patients could be discharged when they tolerated full feedings.

Statistical analysis

Demographic data and operative outcomes were compared between patients who underwent intraumbilical longitudinal incision and those who underwent supraumbilical incision. Statistical analysis was performed using the Fisher's exact test and the Wilcoxon rank sum test. p value < 0.05 was considered significant.

RESULTS

Table 1 summarizes the preoperative characteristics of the patients. A total of 52 patients were diagnosed with hypertrophic pyloric stenosis at our outpatient clinic and underwent pyloromyotomy at the Hospital of Saitama Medical University between April 2005 and February 2018. Twenty-eight infants with hypertrophic pyloric stenosis underwent open pyloromyotomy with a supraumbilical incision between April 2005 and June 2012, and 24 infants underwent open pyloromyotomy with an intraumbilical longitudinal incision at our institution from July 2012 to February 2018. The median pyloric muscle length as measured on ultrasonographic images was 17 mm (range, 15–33 mm) in the intraumbilical longitudinal incision group and 20 mm (15–32 mm) in the supraumbilical incision group, showing a significant difference ($p = 0.035$). There were no significant differences in age, body weight, duration of symptoms before the operation, nor ultrasonographic pyloric muscle thickness between the two groups. No patients were treated with intravenous atropine prior to pyloromyotomy.

All operations could be performed by an intraumbilical longitudinal incision or a supraumbilical

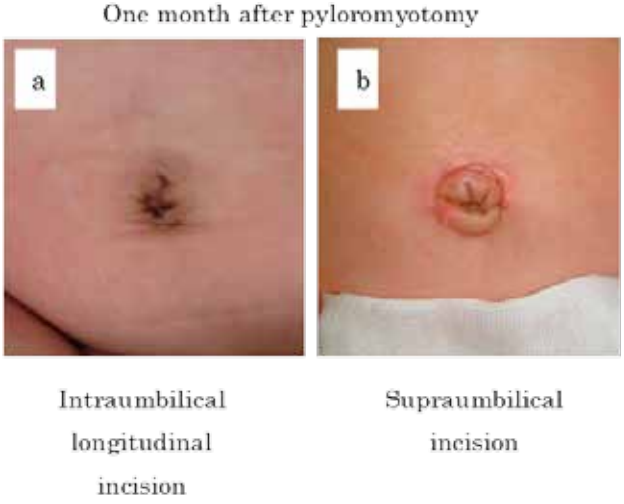

Fig. 2 Cosmetic outcomes
Photographs of the umbilicus one month after the operation in patients who underwent pyloromyotomy with an intraumbilical longitudinal incision (a) or a supraumbilical incision (b). The scar after intraumbilical longitudinal incision was localized inside the umbilicus.

incision without extending the incision or conversion to other approaches. Table 2 summarizes the operative and perioperative results. The operative time was significantly longer in the intraumbilical longitudinal incision group [58.0 min, median (range, 41–129 min) vs. 43.5 min (2–77 min), p = 0.002]. Although there was no significant difference in time to full feeding between the two groups [2 days (2–6 days) vs. 3 days (1–6 days), intraumbilical group vs. supraumbilical group, p = 0.060], the postoperative stay was shorter in the intraumbilical longitudinal incision group [3 days (2–11 days) vs. 5.5 days (2–31 days), p = 0.003]. With regard to complications, the overall incidence was not significantly different between the two groups (4.2% vs. 7.1%, p = 1.0). In the intraumbilical longitudinal incision group, there was only one complication, i.e., wound dehiscence that occurred on postoperative day 5 and was treated conservatively. In the supraumbilical incision group, there were two postoperative complications. One was wound dehiscence that occurred on postoperative day 5, which required resuture under general anesthesia. The other complication was surgical site infection that was treated conservatively. There was no case of mucosal perforation or incomplete pyloromyotomy in either group.

Photographs of the postoperative scar one month after the operation were available in several patients. The postoperative scar after intraumbilical longitudinal incision was localized inside the umbilicus (Fig. 2a). In contrast, supraumbilical incision left a scar outside the umbilicus (Fig. 2b).

DISCUSSION

The results of this study indicated that pyloromyotomy for hypertrophic pyloric stenosis can be performed as safely through an intraumbilical longitudinal incision as through a supraumbilical incision. Although the operative time was longer with the intraumbilical longitudinal incision, this new approach did not result in a high rate of complications nor a longer period of time to full feeding.

Time to full feeding was not significantly different between the two groups, and postoperative hospital stay was significantly shorter in the intraumbilical longitudinal incision group. However, our results do not necessarily indicate that patients who undergo intraumbilical longitudinal incision can be discharged earlier owing to superior improvement of passage of food through the pylorus for two reasons. First, although postoperative feeding was started and increased in accordance with almost the same protocol in the two groups, there may have been minor differences because pyloromyotomy with supraumbilical incision had been performed by a different team of surgeons in a different era. Second, two cases with complications in the supraumbilical incision group who required a long postoperative hospital stay, i.e., 31 days and 14 days, respectively, were likely the cause of this difference.

In case of intraumbilical longitudinal incision, the use of stay sutures on the pylorus to hold the pylorus in position during myotomy, was important from the viewpoint of safety and avoidance of intraoperative complications. We can bring the pylorus into the wound and hold the pylorus in position during the myotomy by retracting the stay sutures. In the present study, we suppose that the use of stay sutures enabled pyloromyotomy without causing mucosal perforation or incomplete pyloromyotomy despite a smaller operative field and a longer distance from the wound to the pylorus by an intraumbilical longitudinal incision than by a supraumbilical incision.

There were several limitations in our study. It was a retrospective study, and there were relatively small numbers of patients in the analysis. In addition, the operation was performed by different teams of pediatric surgeons in a different era between the time when intraumbilical longitudinal incision was performed and the time when supraumbilical incision was performed at our institution. However, we estimate that this did not significantly influence the postoperative results because according to the medical records, the operative technique other than incision and the use of stay sutures, and perioperative management were conducted in the same manner in the two groups. Finally, we could not compare the cosmetic results between the two groups. This is because photographs showing the umbilical scars had been obtained from only a few patients during a short period of time after the surgery and could not be evaluated objectively. In a further study, long-term cosmetic results and a questionnaire survey to patients or their parents are required.

In conclusion, pyloromyotomy through an intraumbilical longitudinal incision, which may offer good cosmetic results, was as effective and safe a procedure

as pyloromyotomy through a supraumbilical incision.

ACKNOWLEDGMENTS

We would like to thank NAI (https://www.nai.co.jp/) for English language editing.

Author contributions: All authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Keisuke Suzuki and Makoto Komura. The first draft of the manuscript was written by Keisuke Suzuki and all authors commented on the manuscript. All authors have read and approved the final manuscript.

FUNDING

This study was not supported by any funding.

COMPLIANCE WITH ETHICAL STANDARDS

Conflict of interest: The authors declare that they have no conflicts of interest.

ETHICAL APPROVAL

All procedures performed in this study were in accordance with the ethical policy of Saitama Medical University and the principles of the Declaration of Helsinki of 1964.

REFERENCES

1) Pollock WF, Norris WJ. Dr. Conrad Ramstedt and pyloromyotomy. Surgery 1957; 42: 966–70.
2) Tan KC, Bianchi A. Circumumbilical incision for pyloromyotomy. Br J Surg 1986; 73: 399.
3) Alain JL, Grousseau D, Terrier G. Extramucosal pyloromyotomy by laparoscopy. Surg Endosc 1991; 5: 174–5.
4) Sathya C, Wayne C, Gotsch A, Vincent J, Sullivan KJ, Nasr A. Laparoscopic versus open pyloromyotomy in infants: a systematic review and meta-analysis. Pediatr Surg Int 2017; 33: 325–33.
5) Hall NJ, Eaton S, Seims A, Leys CM, Densmore JC, Calkins CM *et al*. Risk of incomplete pyloromyotomy and mucosal perforation in open and laparoscopic pyloromyotomy. J Pediatr Surg 2014; 49: 1083–6.
6) Tander B, Shanti CM, Klein MD. Access to the hypertrophic pylorus: does it make a difference to the patient? Eur J Pediatr Surg 2009; 19: 14–6.
7) Kim SS, Lau ST, Lee SL, Schaller R, Jr., Healey PJ, Ledbetter DJ *et al*. Pyloromyotomy: a comparison of laparoscopic, circumumbilical, and right upper quadrant operative techniques. J Am Coll Surg 2005; 201: 66–70.
8) Hall NJ, Pacilli M, Eaton S, Reblock K, Gaines BA, Pastor A *et al*. Recovery after open versus laparoscopic pyloromyotomy for pyloric stenosis: a double-blind multicentre randomised controlled trial. The Lancet 2009; 373: 390–98.
9) Alberti D, Cheli M, Locatelli G. A new technical variant for extramucosal pyloromyotomy: the Tan-Bianchi operation moves to the right. J Pediatr Surg 2004; 39: 53–6.
10) Emil S. Pyloromyotomy through an infra-umbilical incision: open technique and superb cosmesis. Eur J Pediatr Surg 2009; 19: 72–5.
11) Kelay A, Hall NJ. Perioperative Complicati [1] Pollock WF, Norris WJ. Dr. Conrad Ramstedt and pyloromyotomy. Surgery 1957; 42: 966–970.