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The Outcome of Mandibular Distraction Osteogenesis in Infants with Severe Pierre Robin Sequence in Vietnam

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The purpose of this study was to provide the experience of a single center with mandibular distraction osteogenesis (MDO) in Pierre Robin Sequence (PRS) patients. A longitudinal research analysis was conducted to identify PRS patients who underwent MDO at Vietnam National Children's Hospital between 2019 and 2021. The following criteria were used to determine inclusion: 1) those pediatric patients with PRS who were not well handled with conservative therapy, 2) those who received MDO with internal mandibular distractors, and 3) no previous treatment elsewhere. Demographic data, postoperative complications, and surgical results were all evaluated. The inclusion criteria were met by 73 patients. There were no difficulties associated with our distraction strategy. The majority of individuals with tracheostomies were successfully decannulated, and the remainder were able to avoid tracheostomies. Using MDO in PRS is an effective technique to avoid future airway issues. The success rate was lower and the complication rate higher for patients who had a tracheotomy before distraction and for those who underwent distraction at an age older than 2 months. The presence of laryngomalacia, gastric reflux disease, cardiac abnormalities, and GI anomalies did not increase the likelihood of MDO failure in PRS patients.

PRS is a group of birth defects including small jaw and tongue, with or without cleft palate, can lead to airway obstruction at the base of the tongue. The incidence of PRS is quite low, ranging from 1 in 5000 to 1 in 7000 births in the US (1). When the mandible is underdeveloped, it can result in glossoptosis, which then causes problems with eating, sleep-disordered breathing (SDB), and upper airway obstruction (2, 3). In infants with Pierre Robin Sequence, SDB, particularly in the form of obstructive sleep apnea (OSA), is very common, with a prevalence ranging from 85 to 100% (2, 3). OSA in babies is linked to numerous negative health outcomes, including failure to thrive, developmental and learning delays, cor pulmonale, and even death (4). A comprehensive retrospective evaluation revealed that the mortality rate for PRS was 16.7% (5).

MDO described by Molina et al. in 1995 (6) is a relatively new therapy option in young patients with PRS has been become the cost-effective option in comparison to tracheostomy and tongue-lip adhesion (7, 8). Many researchers have reported on the efficacy of MDO in alleviating airway obstruction in the PRS population by gradually extending the jaw and pushing the tongue base forward (9, 10). As a result, MDO can expand supraglottic airspace and frequently reduce upper airway congestion. The effectiveness of distraction is generally evaluated by improvement in clinical examination or polysomnogram results, de-cannulation of tracheostomy, tracheostomy avoidance, reduction in mortality, or changes in airway obstruction patterns (11, 12). By this research, we provide the short-term experience of a single clinic in treating juvenile patients with PRS with mandibular lengthening technique using internal distraction device systems.

MATERIALS AND METHODS

Participants and Study design

We performed the longitudinal study of 143 infants with aged of 1-12 months diagnosed. Here, PRS infants underwent MDO at Vietnam National Children's Hospital in the period of 2019 to 2021. Our study was evaluated and approved by an institutional review board obtained from Hanoi Medical University.

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Inclusion and exclusion criteria

We selected children with a confirmed diagnosis of severe PRS by Otolaryngologists at Vietnam National Children's Hospital. There are 3 inclusion criteria including 1) those pediatric patients with PRS who were not well handled with conservative therapy, 2) those who received MDO with internal mandibular distractors, and 3) no previous treatment elsewhere. We did not include children older than 12 months, lacking information in the medical records. Information on each subject was reviewed simultaneously by 2 independent Otolaryngologists to unify the results. The following criteria: age, incomplete medical records, and lack of pre- or post- MDO Pierre Robin Sequence were excluded. The medical records were checked by 2 independent Otolaryngologists. Especially, with 25% of medical records were reviewed by both with higher than 90% inter-rater reliability.

Preoperative Evaluation

In the event, the continuous pulse oximetry in the prone position is unsuccessful. To circumvent the tongue base, interventions like modified nasopharyngeal tubes and supplemental oxygen are employed. We also continuously monitor each child's feeding response. In case of necessity, early nasogastric feeding will be applied to help supplement nutrition through the gastrointestinal tract, helping children gain optimal weight. In cases where the obstruction is not relieved, the sleep is not of the required quality, and the weight is not growing well, we will consider the surgical option. Therefore, the assessment of the airway in PRS is very important because it affects the decision-making of treatment. All infants had bronchoscopy prior to distraction to ensure that their airways were correctly analyzed. Tracheomalacia or any other anomalies that could not be corrected with distraction were not observed in them. Evaluation of clinical improvement of airway obstruction is spontaneous breathing, clear airway, no need for respiratory support equipment. Evaluation of the possibility of improving the outcome of airway obstruction due to compression: by polysomnography (PSG) after surgery. Evaluation of nutritional status improvement: weight gain, swallowing, oral feeding, feeding equipment before and after surgery.

Technique of Mandibular Distraction Osteogenesis

MDO is surgery to lengthen the lower jaw bone forward, increase the distance from the back of the pharynx to the base of the tongue, lengthen the attachment of the tongue to the lower jaw (the nail plug muscle), pull the tongue forward, and reduce the prolapse of the tongue, and solves airway obstruction in children.

MDO consists of 3 or 5 stages:

- Stage of open surgery to cut bone: cut bone and put bone stretching device.
- Waiting period is about 1-2 days after surgery.
- Stretching phase: when bone relaxation is maximal and new bone tissue is formed, 2 weeks–1 month.
- Consolidation phase: when stretching stops until the stretchers are removed so that new bone tissue is solidified for about 8-10 weeks.
- Completion stage: from removal of the instrument to full functional completion of the stretched bone.

Statistical Analysis

Demographics, operation information, total distraction, consolidation duration, hospital stay, and length of follow up were all gathered. Also documented were postoperative problems and surgical outcomes. Descriptive statistics were used to examine demographic data. A logistic regression analysis was conducted to explore any significant links between complication risk and variables such as gender, age, the presence of other anomalies, and tracheostomy. P-value <0.05 was used to determine statistical significance. The Statistical Package for Social Sciences (SPSS) version 20 was used to analyze data.

RESULTS

In a cohort of 143 infants with PRS, 109 (76.2%) needed airway-related surgery (either mandibular distraction osteogenesis or tracheostomy). 73 infants (66.9%) were eventually enrolled in the study because they met all critical criteria. The average age of the patients at the time of the procedure was 50.1 ± 42.8 days (ranging from 2 to 230 days), with an average hospital stay period of 32.5 ± 17.2 days (ranging from 2 to 105 days). The mean follow-up period was 9.6 ± 3.4 months, ranging from 6 to 15 months, as shown in Table I.

Table I. Demographic data of the patients

Factor	Males (n = 32)	Females (n = 41)	Overall (n = 73)
Age (days)	54.6 ± 48.0	46.5 ± 38.6	50.1 ± 42.8
Follow-up period (months)	9.7 ± 3.3	9.5 ± 3.1	9.6 ± 3.4
Hospital stay (days)	32.9 ± 11.5	33.2 ± 20.7	32.5 ± 17.2
Total distraction (mm)	15.1 ± 2.5	14.8 ± 3.1	14.9 ± 2.6
Consolidation period (days)	96.3 ± 36.1	94.7 ± 22.3	95.4 ± 33.6

Age, follow up, hospital stay, total distraction and consolidation period were calculated as mean ± SD.

Cardiovascular abnormalities (n = 13, 17.8%) and gastroesophageal reflux disease (n =11, 15.1%) were the most prevalent anomalies associated with PRS (Table II).

Table II. Abnormalities occurring concurrently with PRS

	Males	Females	Overall
Cardiac anomalies	7	6	13
GERD	5	6	11
GI anomalies	5	3	8
Laryngomalacia	4	3	7
CNS anomalies	1	4	5
Other anomalies	1	2	3

CNS, central nervous system; GERD, gastroesophageal reflux disease; GI, gastrointestinal.

Other than MDO, several individuals had surgical treatments. The most frequently occurring of these were gastrostomy tube installation (n = 47) and Pre-distraction tracheostomy (n = 14) (Table III).

Table III. Surgical interventions other than mandibular distraction

Surgical Intervention	Males	Females	Overall
Gastrostomy tube placement	23	24	47
Pre-distraction tracheostomy	4	10	14
Cleft palate repair	3	5	8
Nissen fundoplication	2	3	5

All patients had effective mandibular distraction, with significant advancement of the lower jaw. The MDO resulted in a change in occlusion from class II to class I, with 2 to 3 mm overcorrection resulting in class III (according to Caouette-Laberger). The mean distraction achieved with internal devices was 14.9 ± 2.6 mm (range 9.3–18.2 mm), as shown in Table I. They also were released on 100% oral feeds. The NG was withdrawn one month after the MDO was completed to ensure that patients accepted feeds without difficulty. The complication rate was 30.1% (n = 22). Among the 22 patients who experienced problems, 19 (26.0%) had soft tissue infection, and 3 (4.1%) had recurrent symptoms of obstructive sleep apnea (OSA) despite MDO being conducted successfully (Table IV).

Table IV. Related Complications

	Males	Females	Overall
Infection	8	11	19
Superficial infections	7	9	16
Cheek abscess	1	2	3
Postoperative sleep apnea (OSA)	1	2	3
Re-operation	0	0	0

Table IV showed that there were 16 patients (21.9%) had superficial infections occurred around the site of distraction on the arm, but they were treated conservatively without requiring removal of the hardware. Three patients (4.1%) had a cheek abscess due to deep surgical site infection, which was managed with drainage and irrigation and had no effect on the distraction outcome. A PRS patient who had a tracheostomy during infancy underwent MDO at one year of age, resulting in successful correction of retrognathia (approximately 18 mm were gained during distraction). However, the patient continued to exhibit symptoms of obstructive sleep apnea (OSA) after the distraction procedure, which required the use of continuous positive airway pressure (CPAP) and delayed decannulation until the age of two.

Statistic Result

The frequency of complications was assessed by considering variables including gender, presented age, the presence of accompanying abnormalities such as cardiac anomalies, and whether the patient had undergone tracheostomy prior to the procedure. Complication risk was not significantly connected with gender (P = 0.514), age at presentation (P = 0.935), existence of additional anomalies (P = 0.822), or presence of tracheostomy (P = 0.896), according to statistical analysis.

Table V. Logistic regression some factors affecting the risk of complications

	Have complication	
	OR (95%CI)	p value
Age (day)	0.921 (0.612–1.365)	0.935
Gender (Ref: Female)		
Male	1.216 (0.735–2.157)	0.514
Existence of additional anomalies (Ref: No) Yes	1.082(0.795–1.466)	0.822
Presence of tracheostomy (Ref: No) Yes	1.107(0.804–1.351)	0.896

Figure 1. Photographs of the patient before and after she had undergone mandibular distraction osteogenesis

DISCUSSION

MDO is a successful treatment for infants with PRS who experience significant airway obstruction. Additionally, the use of external distractors for MDO has been extensively explore as reported (6–8). The key advantages of these devices are that they do not require a second surgery to remove and that they can travel in multiple directions. However, significant downsides have been documented, including pin-site facial scarring, patient pain, and greater exposure of the device to external damage, which may result in pin loosening/dislodgement, reduction of the device's retention time, and higher recurrence. The utilization of internal distractors in MDO has gained popularity due to its advantages, such as increased stability as it is not exposed to external trauma forces. Furthermore, utilizing a longer consolidation period after the procedure allows for improved ossification and a reduced risk of relapse. Additionally, the resulting scar in the submandibular region is considered more aesthetically pleasing (13, 14).

A 9-year retrospective study conducted by C. K. Koustad et al. recommended the use of MDO in infants to treat severe upper airway blockage and avoid the need for tracheostomy (15). Infants with mild PRS are managed conservatively through patient positioning and nasal cannula oxygen supplementation, while those with severe PRS are intubated and scheduled for distraction within the same week. Brian T. Andrews et al. found that 51.7% of undistracted patients had other airway defects (e.g., subglottic stenosis, tracheomalacia) that would likely impact their distraction outcomes if they had not been prescreened (16).

Denny AD et al. recommend distracting the mandible until the maxillary and mandibular alveolar crests are well aligned (17), while Senders CW et al. suggest distracting the mandible until it projects 2 to 3 mm beyond the maxillary alveolar ridge to allow for future bony relapse (18). Senders CW et al. also caution against over distraction as it may lead to future bony relapse or differential maxillary to mandibular growth. In this study, distraction was continued until class III was achieved, with the goal of significantly increasing the retroglossal airway and preventing future relapse (18).

Flores RL et al. in a retrospective, database driven study found that the fewer days a child was treated, the better the outcome: Infants with PRS who underwent distraction before 30 days of age were found to have a higher success rate in terms of respiratory status than those older than 2 months. This suggests that physiological changes may become entrenched and irreversible beyond a certain age, even with intervention.

Similarly, Tahiri et al. reported a higher complication risk in patients who were distracted at an older age. The mean age of patients who suffered issues in their study was 36.9 months, which was almost 1.5 years older than the mean age of all patients (12). In this case, three patients (4.1%) had a tracheostomy at an age older than 3 years. Despite successful decannulation following MDO, two of these cases had unsatisfactory outcomes, with one requiring additional distraction and the other needing CPAP for chronic OSA. The statistical analysis did not indicate a significant correlation between patient age at presentation and the risk of complications.

Similarly, the presence of a tracheostomy did not increase the risk of complications in MDO for PRS, as identified by Flores et al. (19). Previous studies on MDO did not focus on its limitations in treating individuals with PRS. However, Flores et al. identified several factors that could predict the likelihood of MDO failure in PRS patients, including GORD, age older than 30 days, neurologic abnormalities, airway anomalies other than laryngomalacia, intact palate, and preoperative intubation. In this study, statistical analysis did not reveal any factors that increased the risk of complications.

Tholpady et al. shared their findings on the use of mandibular distraction in infants with PRS and concomitant laryngomalacia. They found that 23% of newborns with PRS developed laryngomalacia, which required MDO. The authors suggest that lengthening the anterior peri laryngeal tissue, including the extrinsic suprahyoid laryngeal muscles, enhances the diameter and flexibility of the airway. As a result, this corrects laryngomalacia and glossoptosis, and avoids the need for tracheostomy (20). This was also observed in our investigation, since we documented two cases of PRS with contemporaneous laryngomalacia. With the improvement of airway blockage, one of them was able to avoid tracheostomy. De-cannulation was successful in the second instance, which had previously been tracheostomized. None of them displayed any recurrence of airway blockage that necessitated intervention during the follow-up period.

Concerning feeding after MDO in PRS infants, studies have shown a considerable improvement in swallowing function after MDO (21, 22). As a result, the infants can feed orally when they are weaned from NG tubes pre-operatively. Hong et al. found that MDO improved eating and swallowing performance in all of their PRS infants, which was validated by video fluoroscopic swallow investigations. In the current study, feeding was improved in all infants, including those who had a preoperatively implanted NG and were weaned after MDO.

There are some limitations to this study that should be considered. Although the population of the study is limited in absolute terms, the rarity of PRS makes it difficult to collect a large number of infants at a hospital. Furthermore, all of the infants included had severe airway disease, which may restrict the general application of

our findings to PRS infants with a more typical distribution of airway severity, as well as those offering alternative procedures such as tongue lip adhesion. Due to the limited number of patients, some estimates of the association of complications may not be really accurate. More research is needed on this issue.

CONCLUSION

Using MDO in PRS is an effective technique to avoid future airway issues. Infants who required a tracheotomy prior to distraction and situations where distraction was performed at an older age (>2 months) had a lower success rate and a higher rate of complications. Laryngomalacia, gastric reflux disease, cardiac abnormalities, and GI anomalies are not related with increased MDO failure rates in PRS.

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