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Congenital Pyriform Sinus Fistula: Systematic Review and Proposal for Treatment Using a Novel Endoscopic Approach

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ABSTRACT

The pyriform sinus fistula (PSF) is a congenital developmental defect of the third or fourth branchial pouch. It presents as acute inflammatory swelling of the neck with recurrent deep neck abscesses, recurrent neck cystic lesions or suppurative thyroiditis. The literature reports various surgical approaches to treat this condition in children. A systematic review of the literature related to management protocols for PSF was conducted and we report a case exemplifying treatment in our department. Traditionally, treatment for PSF has been open surgery; however, in the last few decades, the minimally invasive transoral endoscopic approach has gained in importance, demonstrating long-term outcomes comparable to open surgery and with lower morbidity, and it has now become the first-choice treatment. We further describe a case of PSF treated by a transoral endoscopic approach with electric cauterization, fibrin glue obliteration of the fistula and Polydimethylsiloxane (Vox-Implants®, Bioplasty, Geleen, The Netherlands) submucosal injection. According to the authors, application of Vox-Implants® injection, in addition to standard techniques, may be helpful to reduce fistula recurrence rate after surgery.

Keywords: Abscess, congenital, fistula, neck, polydimethylsiloxane, pyriform, sinus, surgery, transoral

Introduction

The pyriform sinus fistula (PSF) is a congenital developmental defect of the embryonal third or fourth branchial pouch which leads to abnormal communication between the mucosa of the pyriform fossa and the neck. Despite its first description in 1973,[1] PSF has generally been considered a very rare entity but has become increasingly reported in recent years. It represents 3-10% of branchial pouch defects[2,3] and is derived from failed obliteration of the third or fourth branchial pouch. Theoretically, a third or fourth branchial fistula follows a "two-loop course," originating from the caudal end of the pyriform fossa, posterior to the fold made by the internal laryngeal nerve, and coursing inferiorly along the tracheoesophageal groove, posterior to the thyroid gland, into the mediastinum, to loop around the aorta (if on the left side) or the subclavian artery (if on the right side).[4,5] More recently, the thymopharyngeal duct, a third pouch derivative independent of the third and fourth fistula tracts, has been proposed as an alternative cause of these lesions. Third or fourth branchial remnants almost always occur on the left side.[6,7]

Pyriform sinus fistula can affect all age groups, but it is more common in the pediatric population.[8] It frequently presents as upper respiratory tract infection, acute inflammatory swelling of the neck with recurrent deep neck abscesses, recurrent neck cystic lesions, or suppurative thyroiditis.[8,9] Clinical presentation changes with age,[4] and in the neonate, these anomalies can rapidly lead to tracheal compression and respiratory distress.[10] Therefore, it is very important to make an accurate diagnosis as early as possible. Barium swallow x-ray may be helpful in fistula identification; however, direct laryngoscopy performed in an operating room with the exploration of the pyriform fossa plays a fundamental role in the diagnosis.[6]

For many years, the standard treatment was complete excision of the fistula tract using open surgery. Currently, minimally invasive endoscopic transoral approaches are becoming increasingly frequent. We have performed a systematic review of the literature about the current management of PSFs in children, focusing on clinical and surgical aspects. Finally, we report our personal experience, describing a case diagnosed and surgically treated in our department.

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Methods

This study is a systematic review following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines.[11]

A systematic review of the literature was conducted using the PubMed and MEDLINE databases. We searched for articles published between January 1973 and December 2020, relating to patients affected by pyriform sinus fistula, using the following search words: "pyriform sinus fistula" AND "recurrent neck abscess" AND "child AND children," "pyriform sinus fistula" AND "recurrent neck abscess" AND "infant AND infants," "pyriform sinus fistula."

The reference lists of all articles identified were examined for additional relevant studies. The selection of articles included in the systematic review was based on the following eligibility criteria: diagnosis of at least 3 cases of PSF in children, age (0-18 years), presence of a detailed description of clinical management, and surgical procedures. Papers with no abstract or no full text available, those considered irrelevant for the proposed subject of this study, and those written in languages other than English were excluded. Articles identified were assessed in 2 steps, first analyzing the abstracts and then reading the full articles. Case series meeting the eligibility criteria were included in our systematic review.

Results

In total, 498 articles were initially identified. Cross-checking of articles led to the exclusion of 174 duplicates. The remaining 324 papers were screened checking the abstracts according to previously established eligibility criteria. During the first check, we excluded a total of 281 articles: in 158, the main topic was not related to the primary object of our research, 77 were not in English, 36 had no abstract available, and 10 presented series of less than 3 patients. The second check was carried out on the remaining 43 articles analyzing the full text. Of these, 3 articles had no full text available and were excluded, in 14 the main topic was not related to our subject, and in 11 details about the surgical procedure were not described.

Finally, 15 articles were included in our systematic review. Each contained between 5 and 191 cases (ranging in age from 0 to 18 years) treated in the same institute (Table 1). In three articles, all patients were treated with an open surgical approach; 6 articles reported patients treated only with a transoral endoscopic approach; in 6 articles, both approaches were used. Surgical data are summarized in Table 2.

A flowchart of the results of the literature search is shown in Figure 1.

Case Exemplifying Diagnosis and Treatment

In August 2018, a 10-year-old boy presented at our ER with a 1-week history of sore throat, fever, fatigue, and a painful left-side neck swelling. He had been treated with broad-spectrum antibiotic therapy for a week without remission of symptoms. Computed tomography (CT) with contrast revealed an approximately 3.5-cm-sized abscess pocket in the left parapharyngeal space (Figure 2).

The child was admitted to the pediatric department in our hospital, and surgical drainage of the abscess was performed. Samples were collected to test for mycobacteria but bacterial culture and microscopic examination were negative. Moreover, viral serologies were all negative. On postoperative day 7, a neck ultrasound (US) confirmed the absence of a remnant

Table 1. Summary of published case series with pyriform sinus fistula: demographic information and clinical characteristics at presentation

Series (Author, Year, Reference)	No Cases	Age at Onset (Years)	Symptoms
Narcy et al., 1988[1]	8	0-18	3 NT, 5 NA (2 AST)
Lin et al. 1991[9]	16	0-16	5 AST, 5 NF, 4 NM, 1 NA, 1 ES
Hashizume et al. 1993[23]	11	0-14	9 NS, 2 NT
Park et al. 2000[20]	11	0-18	11 NA
Verret et al. 2004[18]	10	0-10	1 AST, 9 NA
Pereira et al. 2006[3]	8	1-16	4 AST, 1 NM, 1 NS, 2 AS
Smith et al. 2008[17]	5	0-13	5 AST
Chen EY et al., 2009[21]	9	3-16	9 NA
Leboulanger et al. 2010[15]	20	0-18	7 NS, 13 NA
Watson et al. 2013[26]	5	4-11	5 NA
Sun et al. 2014[6]	23	2-14	21 NA, 2 AST
Huang et al. 2016[27]	5	5-7	5 AST
Wang et al. 2017[28]	108	-	58 NA, 33 NS, 17 NM
Sheng et al. 2019[16]	190	0-12	23 NM, 142 NA, 20 AST, 5 TN
Chen T et al. 2020[19]	191	0-13	140 NA, 41 NM, 8 AST, 2 TN

NT, neck tumor; NS, neck swelling; NA, neck abscess; AST, acute suppurative thyroiditis; NF, neck fistula; TN, thyroid nodule, ES, esophageal stricture, AS, asymptomatic.

Table 2. Articles by author with study information including type of surgery performed and total number of cases

Authors	No. of Cases	Open Surgery	Endoscopic Transoral Surgery								
			Elettrocauterization	Silver Nitrate	Fibrin Glue	Trichloroacetic Acid	Thallium Laser	CO_2 Laser	KTP Diode Laser	Radiofrequency	Observation
Narcy et al., 1988[1]	8	6	2	0	0	0	0	0	0	0	0
Lin et al. 1991[9]	16	16	0	0	0	0	0	0	0	0	0
Hashizume et al. 1993[23]	11	11	0	0	0	0	0	0	0	0	0
Park et al. 2000[20]	11	0	0	0	0	11	0	0	0	0	0
Verret et al. 2004[18]	10	0	10	0	0	0	0	0	0	0	0
Pereira et al. 2006[3]	8	5	0	1	0	0	0	0	0	0	2
Smith et al. 2008[17]	5	3	0	2	0	0	0	0	0	0	0
Chen EY et al. 2009[21]	9	6	3	0	0	0	0	0	0	0	0
Leboulanger et al. 2010[15]	20	1	2	0	0	0	4	13	0	0	0
Watson et al. 2013[26]	5	0	1	2	0	0	0	2[a]	0	0	0
Sun et al. 2014[6]	23	0	23[b]	0	0	0	0	0	0	0	0
Huang et al. 2016[27]	5	0	0	0	5[c]	0	0	0	5[c]	0	0
Wang et al. 2017[28]	104	0	0	0	0	0	0	104	0	0	0
Sheng et al. 2019[16]	190	190[d]	0	0	0	0	0	0	0	0	0
Chen T et al. 2020[19]	191	143[d]	0	0	0	0	0	0	0	48	0

[a]CO_2 laser-silver nitrate combined technique.
[b]Case treated with combined technique, electrocauterization of the fistulous internal opening, and open surgery.
[c]All patients underwent KTP laser-assisted—endoscopic tissue fibrin glue biocauterization as a treatment for PSF.
[d]Endoscopic-assisted open surgery.

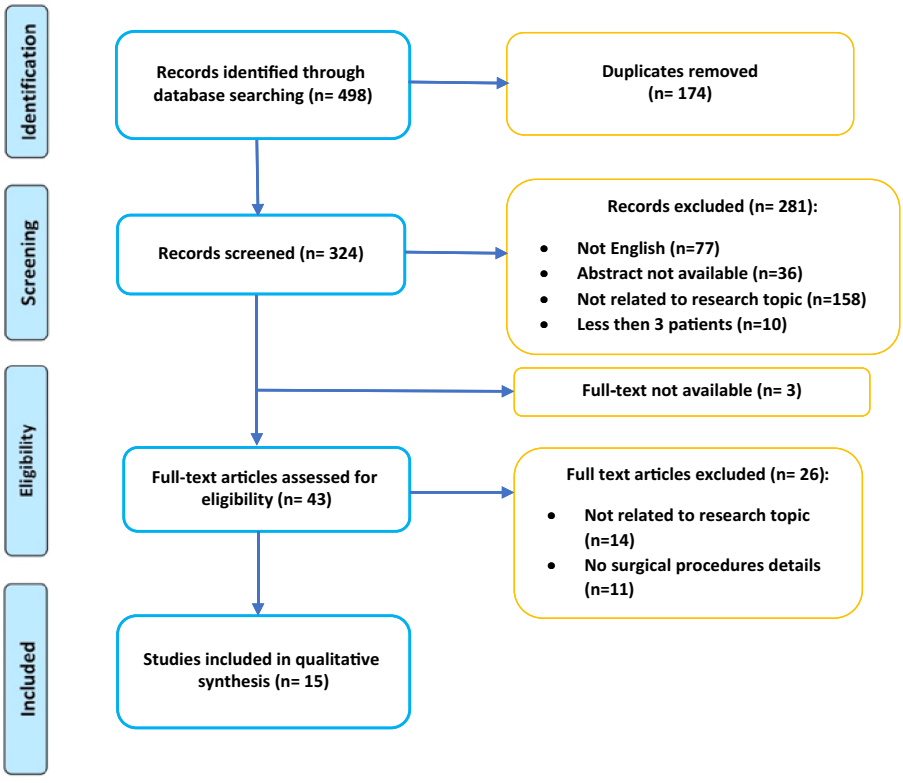

Figure 1. Literature search strategy (PRISMA format).[11] PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

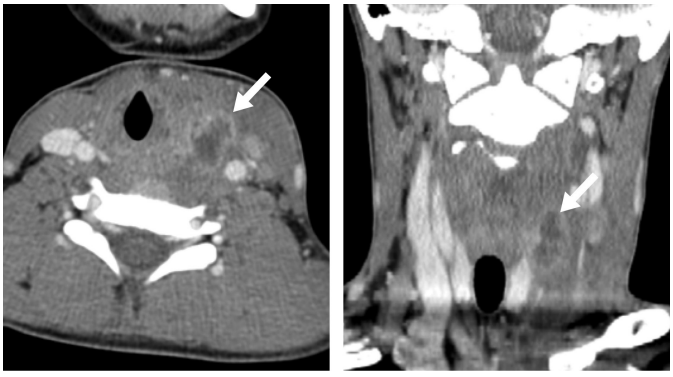

Figure 2. CT scan of neck of 10-year-old patient affected by left neck abscess (arrow) related to pyriform sinus fistula. Often the fistula is not clearly visualized with an ordinary CT scan during an infection of the neck. CT, computed tomography.

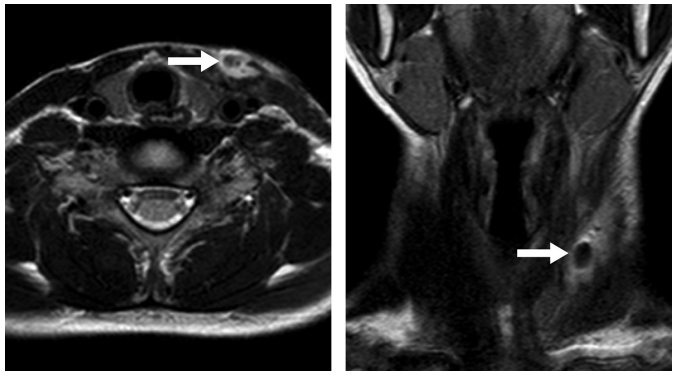

Figure 3. The child came to our attention several months later for a recurrence of left cervical swelling with neck fistulization (arrow). MRI with gadolinium showed a neck abscess on the left side. MRI, magnetic resonance imaging.

abscess pocket, and the patient was discharged. The patient seemed to be healed uneventfully.

Eleven months later, the child was readmitted for a recurrence of left cervical swelling. A neck US in the ER showed a recurrence of a cervical abscess on the left side but not as deep as the previous abscess. After 6 days of intravenous antibiotic therapy, MRI with contrast was performed (Figure 3): abscess size had increased, consequently, it was drained in the operating room once more. Postoperative neck US control on postoperative day 7 showed a small residual pocket supposedly in communication with the hypopharynx. Due to the recurrence of the abscess on the same side, suspicion of the presence of a pyriform sinus fistula was confirmed by barium swallow x-ray examination (Figure 4) and direct laryngoscopy performed in the operating room (Figure 5). Therefore, a nasogastric tube was placed withholding oral food.

The PSF has treated with the transoral technique under suspension laryngoscopy: electric cauterization, fibrin glue obliteration of the fistula, and Vox-Implants® injection was performed in the surrounding healthy mucosa. A 2 mL aliquot of Vox-Implants® was injected until the lateral wall was filled occluding the fistula opening.

Using laryngoscopy and barium swallow x-ray, the fistula was confirmed to be closed (Figure 6) and 1 month after surgery, the

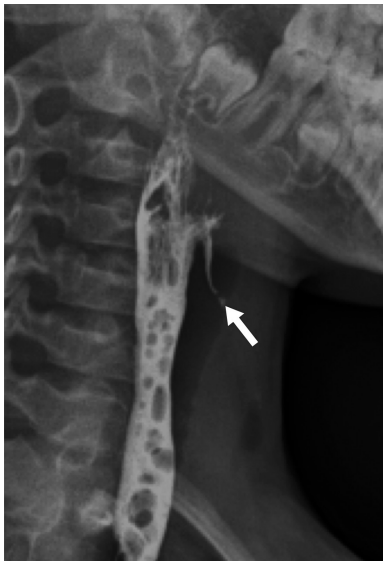

Figure 4. After drainage of the neck abscess, on postoperative day 7, neck US control showed a small residual pocket supposedly in communication with the hypopharynx. Barium swallow x-ray examination confirmed the suspicion of pyriform sinus fistula. US, ultrasound.

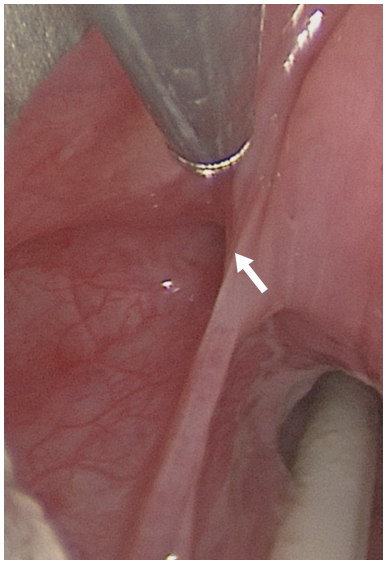

Figure 5. Direct laryngoscopy performed in operating room showed pyriform sinus fistula (arrow).

nasogastric tube was removed. No recurrence was detected during 12 months of follow-up.

Discussion

The PSF is a congenital cervical deformity resulting from incomplete degeneration of the third and fourth branchial pouch during early embryonic development. The diagnosis of PSF is challenging because this condition is uncommon, and its presentation is unspecific. Moreover, clinical presentations vary with age. A neck cyst is a common clinical finding among neonatal patients. It may be infected and compress the surrounding structure. Recently, prenatal diagnosis has been performed based on ultrasonography and MRI findings, and the ex utero intrapartum treatment procedure was applied in some cases.[12–15] On the other hand, PSF in older children commonly presents with acute inflammatory swelling of the neck with recurrent deep neck abscesses, recurrent neck cystic lesions, or suppurative thyroiditis, especially on the left side.[16,17] Unfortunately, misdiagnosis is common in both newborns and children: PSF often remains undiagnosed for several years, and patients usually present to the surgeon after multiple infections requesting incision and drainage procedures.[2,6,7,18,19] Therefore, in patients who present with recurrent neck abscesses or suppurative thyroiditis, the possibility of a PSF should be kept in mind.[2,10] When PSF is suspected, usually an US scan, CT, or MRI has already been carried out.[20] These investigation techniques are very useful for abscess examination but less useful in searching for a fistula. Barium swallow x-ray has a greater sensibility and may be more helpful in fistula identification, as occurred in our case. However, it has limited value in newborns. Direct laryngoscopy performed in an operating room with the exploration of the pyriform fossa plays an important role in the final diagnosis, allowing clear visualization of the fistula.[18,19,21,22]

Figure 6. Barium x-ray examination 10 days after surgery. No evidence of recurrence.

Traditionally, treatment of PSF has been by open surgery with complete excision of the fistula and, if an abscess or granulation tissue is found around the thyroid gland, a hemithyroidectomy should be performed.[23] An endoscopic-assisted technique has also been described for examination of the pyriform sinus with cannulation or dye injection of the tract so that the remnant tract could easily be reached.[24] Although the rate of recurrence is low, these open procedures predispose the patient to possible complications. Open procedures have their potential risks, and it has been reported that 5% of patients who received open neck surgery for third and fourth branchial pouch anomalies had complications including vocal cord paralysis/paresis, salivary fistulas, and recurrent infection.[22] In the last few decades, a minimally invasive endoscopic approach has gained in importance. Many studies have been performed to evaluate the long-term effectiveness and safety of the endoscopic transoral approach: they demonstrated that this procedure can be considered a definitive treatment for PSF. Open approaches with excision of the sinus

tract often with hemithyroidectomy should be reserved for the minority of patients who continue to have recurrent left neck abscesses.[2,6,19,21]

Different techniques for endoscopic obliteration of the internal opening of a PSF are described in the literature: electrocauterization, laser obliteration (CO_2, Thallium), chemo-cauterization (trichloroacetic acid [TCA] or silver nitrate), fibrin glue obliteration, suture, or combined techniques.[25–28]

In our exemplary case, we performed a transoral endoscopic approach using a combination of different techniques to reduce the risk of recurrence: electrocautery of the margins of the fistula, fibrin glue injection inside the fistula, and Vox-Implants® (Bioplasty) injection in the submucosa.

Vox-Implants® is an injectable suspension of solid textured granules of an elastomer of polydimethylsiloxane (PDMS) in a hydrogel of polyvinylpyrrolidone. Polydimethylsiloxane is a biocompatible, non-pyrogenic solid, and irregular textured silicon-based organic polymer. The diameter of the particles avoids distant migration from the site of injection, while texturization facilitates mechanical bonds between particles and host tissues, favoring the formation of a fibrous envelope all around the particles, and making the tissue augmentation stable and long-lasting.[29] Currently, it has numerous applications in medicine and surgery thanks to its well-known stability and tolerance in human tissues. It has been reported to be an ideal filling material with no pattern of degradation or surface distortion, not absorbable, even under its safety profile if injected into the subcutaneous or submucosal space.[30] Principal applications reported in ENT and head and neck surgery are voice rehabilitation in vocal fold palsy,[31–33] treatment of the patulous Eustachian tube,[34,35] injection laryngoplasties in cases of phonatory prostheses leakage,[36,37] and in cases of reconstructive laryngectomy to give better continence of the neoglottis.[38]

Radiologists and ENT specialists may benefit from a knowledge of the radiologic characteristics of Vox-Implants®, especially the MRI signal, and variability in appearance in human tissue, to improve image interpretation. Specific radiological features of PDMS seem to change in relation to the temporal gap between the injection and MRI study, and this modification is mostly seen on T2-weighted images of the head and neck region. In particular, in the early stages after injection, there is a clear hyperintensity of the signal, giving a good spatial definition of the surrounding tissue in relation to the injected site. Magnetic resonance imaging appearance may change over time since the T2-weighted hyperintensity seems to gradually attenuate switching to an iso- or hypointensity. This is consistent with histological data obtained in several studies, where it has been documented that PDMS gradually integrates with tissues by forming a fibrous envelope.[39] The change in the MRI signal could be helpful to evaluate the status of treatment and follow-up.

In the authors' opinion, injection of Vox-Implants® into healthy mucosa surrounding the fistula opening in the pyriform sinus, in addition to other standard techniques for fistula closure such as cauterization, may be helpful to reduce the recurrence rate after surgery. As far as we know, this is the first time that Vox-Implants® has been used for this type of pathology and further applications and studies are needed to support this hypothesis.

Conclusion

The PSF is a rare congenital anomaly that usually presents as acute inflammatory swelling of the neck with recurrent deep neck abscesses, recurrent neck cystic lesions, or suppurative thyroiditis. It not only presents most commonly in the pediatric population but can also affect all age groups. Ultrasound, CT, and MRI, generally used in the diagnosis of neck abscesses, may be inadequate for PSF diagnosis. A child presenting with recurrent neck abscesses is a clinical scenario that should suggest performing a barium swallow x-ray and a direct laryngoscopy. Obliteration of the internal opening of the PSF with an endoscopic transoral approach is a minimally invasive, effective, and safe surgical procedure; for these reasons, it is now considered to be the first-line treatment. Different techniques are described in the literature: electrocauterization, chemocauterization, laser obliteration, fibrin glue obliteration, suture, or combined techniques. According to the authors, the application of Vox-Implants® injection, in addition to standard techniques, may be helpful to reduce the fistula recurrence rate after surgery.

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