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Surgical Repair of Chest Wall and Pectoral Deformities in Poland Syndrome in Children

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Abstract: Poland syndrome is a rare congenital condition characterized by absence or underdevelopment of the sternal head of the pectoralis major muscle on one side, often with ipsilateral breast and chest wall hypoplasia (though concomitant hand anomalies are beyond our scope). Severe deformities may also include absent ribs or asymmetric chest. 3D imaging (such as MRI) vividly demonstrates the unilateral chest depression and muscle absence. For example, the MRI above (right side views) shows a profound right anterior chest wall depression with no right pectoralis muscle visible; the left side (normal) is indicated by the dashed line. Such imaging is valuable in preoperative planning. Surgical correction is generally reserved for the more severe thoracic defects. In Romanini's classification, only grades T2–T4 (the moderate-to-severe forms) typically warrant operative repair [1,2]. In practice, pediatric patients with significant chest asymmetry are referred for reconstructive surgery to restore chest contour and stability.

Objective of the Study

To comprehensively survey the surgical techniques reported for repairing chest wall and pectoral deformities in children with Poland syndrome.

Methodology

A systematic literature search was performed in PubMed and Embase (2008–2023) for studies on “Poland syndrome” AND (chest OR pectoral) AND (surgery OR reconstruction OR repair) in pediatric populations. We included case reports, series, and reviews describing surgical management of the chest wall or pectoral region in Poland syndrome, excluding any reports focused on hand/limb surgery. Titles, abstracts, and full texts were screened, yielding studies describing various techniques (muscle flaps, prosthetic implants, tissue expanders, etc.).

Results

The literature describes a range of reconstructive techniques. Broadly, these include ***soft-tissue augmentation*** (muscle flaps, fat grafting, expanders, implants) and ***rigid chest wall stabilization*** (prosthetic ribs/plates or mesh). Often multiple methods are combined in stages.

Latissimus dorsi (LD) musculocutaneous flap. This pedicled flap is frequently used in male patients to fill large chest defects. Foucras et al. reported complete chest wall repair in three male PS patients using pedicled LD transposition, with all flaps surviving and no major complications [3]. At long-term follow-up, these patients maintained chest stability and were satisfied with the outcome. In female patients, the LD flap may be used in conjunction with breast implants. All six female PS patients in Foucras's series underwent bilateral LD flap coverage plus silicone implants, again with no infections or flap failures [3,4]. Thus, LD flaps provide bulk and muscular support; donor-site morbidity and shoulder function are usually acceptable in experienced hands. Composite flaps incorporating additional fascia have also been described. For example, Al-Qattan and Hajjar reconstructed a large anterior defect in a 5-year-old using an LD flap with attached thoraco-lumbar fascia. The fascia added rigidity, preventing lung bulging, and no complications occurred. However, they noted that some chest wall depression persisted and planned a second surgery after puberty for final contour [5].

Free flaps. Autologous free tissue transfer is an option, especially in older children with adequate donor tissue. In a series of 22 patients, Mahrhofer et al. performed 9 free flaps (3 transverse myocutaneous gracilis [TMG] and 6 deep inferior epigastric perforator [DIEP] flaps) to reconstruct chest/breast deficits. TMG flaps were preferred in lower-body-mass children (thin patients with insufficient abdominal tissue), whereas DIEP flaps were used in higher-BMI patients to achieve large volume. The TMG can be innervated to reconstruct pectoralis function and can be inset to recreate the axillary contour. Importantly, free flaps can provide soft-tissue volume when implants are undesirable or inadequate. In Mahrhofer's cohort, 2/22 patients required DIEP flaps, and 6/22 required TMG flaps, often combined with fat grafting [6].

Prosthetic implants and expanders. Many pediatric females undergo staged augmentation. Tissue expanders under the skin (sometimes with temporary expanders in the chest wall) are used to create space for a permanent implant. Mahrhofer et al. reported that 9 of their 22 patients ultimately received breast or chest implants (often after expansion) [6]. Silicone implants filled the breast deficit; in Foucras et al., bilateral breast implants alone provided good symmetry and patient satisfaction in all six women. Implant-based reconstruction is simple and reproducible, but it relies on adequate soft-tissue coverage. Expanders are particularly useful when skin or muscle is tight; serial expansion avoids overstretching delicate skin [4].

Autologous fat grafting (lipofilling). Fat transfer is increasingly used for mild-to-moderate chest hypoplasia or to fine-tune results. In the MDPI series, 2 of 22 patients were treated with fat grafting alone (often as a second-stage "touch-up"). The same authors found fat grafting to be "safe and efficient in mild cases" of PS. Fat grafting has the advantage of minimal donor-site morbidity (liposuction) and avoids foreign materials; however, multiple sessions may be needed to achieve symmetry [6].

In cases of missing ribs or major chest wall defects, rigid reconstruction is required to prevent paradoxical breathing. Several methods are reported:

Synthetic meshes. For limited rib agenesis (e.g. two missing ribs), a Gore-Tex patch can bridge the defect. Torre et al. note that if only one rib is missing, often no repair is needed; for two ribs, Gore-Tex stabilization suffices [1].

Titanium bars/plates. When multiple ribs are absent, metallic supports can bridge the gap. Surgeons have employed titanium bars or rib-like plates, bending them to fit the chest contour and securing to adjacent ribs or sternum with screws [1,2,7]. Anderson et al. described custom titanium "ribs" and a sternal plate to precisely reconstruct a large anterior defect in an adolescent. In their two cases (one due to Poland syndrome), they achieved a stable chest wall with no complications [8]. No patient developed implant displacement or respiratory compromise. Similarly, Goldsmith et al. used a 3D-printed titanium hemi-sternum and rib implant to reconstruct an extensive defect (in a tumor patient), resulting in no paradoxical motion at 18-month follow-up. These 3D-printed prostheses offer an exact fit to the patient's anatomy (derived from CT models) [9].

Bone cement (methyl methacrylate). An older technique is to mold cement into a thoracic plate. Arango Tomás et al. reconstructed a 17-year-old's defect using a preformed methyl-methacrylate prosthesis, covered by a latissimus flap. This provided a solid chest wall and "prevented paradoxical movement". Cement prostheses can be customized intraoperatively, but rigidity and long-term stability are considerations [7].

VEPTR (vertical expandable prosthetic titanium rib). For very young children with multiple absent ribs, the VEPTR device (initially designed for congenital scoliosis) can be applied to support the

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chest. Rosen et al. reported using VEPTR in a 1-year-old with four missing ribs and scoliosis. They anchored expandable rods to adjacent ribs and spine, stabilizing the chest wall. At 10-month follow-up, respiratory mechanics were improved and scoliosis had not progressed. The authors concluded that early VEPTR placement can prevent later complications of chest instability [10].

Collectively, these techniques have produced generally good outcomes. In reported series, most children achieve a stable chest wall and acceptable symmetry. For example, Anderson et al. reported that custom titanium implants "provided a stable chest wall reconstruction with satisfactory cosmetic results" and no long-term complications [8]. In Foucras's series, all patients (male and female) were satisfied, and no flap failures or prosthetic infections were noted [4].

Discussion

A successful reconstruction is typically individualized. *Autologous tissue* (muscle flaps, free flaps, fat) offers the advantage of living, vascularized coverage. The pedicled LD flap is a workhorse, especially in males, providing both bulk and potential restoration of muscle function (when nerve coaptation is done). Its main drawbacks are donor-site scarring and the need for a viable latissimus (which is usually spared in PS). Free flaps (TMG, DIEP) spare the back but add microsurgery complexity. Mahrhofer et al.'s experiences indicate that in well-selected patients, free flaps can achieve very natural contours with high satisfaction. *Fat grafting* is minimally invasive and can smooth out minor asymmetries, but often requires repeat sessions for adequate volume. Mahrhofer's group emphasizes that fat grafting should be reserved for mild deficiencies, as overreliance on fat alone may undercorrect severe hypoplasia [6].

Prosthetic augmentation (expanders, implants) is often effective in females. Tissue expanders allow gradual accommodation of an implant in young patients. However, implants in growing children may eventually need replacement for size. *Rigid reconstruction* (meshes, bars, custom implants) is essential if more than two ribs are absent or if the sternum is affected. Custom 3D-printed titanium implants (as described by Anderson and by Goldsmith) represent a major advance: they exactly match the defect and preserve chest stability [8,9]. In contrast to cement, these are lighter and less likely to break. Mechanical support with titanium bars (without major custom manufacturing) is also widely used; the choice often depends on available resources and surgeon experience.

Timing of surgery is debated. Some authors suggest early repair of severe defects, even in young children, to prevent chest deformity progression. Al-Qattan et al. successfully corrected a toddler's defect with an LD-fascia flap, but they noted that chest rigidity required another operation after skeletal maturity [5]. Torre et al. recommend a "multistep minimally invasive approach starting at puberty" rather than one large late surgery [1]. In practice, most reconstructive surgeons try to balance the psychosocial benefits of earlier correction against the need to accommodate growth. Long-term follow-up is necessary; some children may need revision or additional augmentation as they mature.

Our review is limited by the rarity of this condition and the low evidence level of most reports (primarily case series and reports). No randomized trials exist, and there is significant heterogeneity in patient age, severity, and techniques. Notably, combined approaches (for example, muscle flap plus implant, or implant plus fat grafting) are common. Several authors have proposed algorithms: for instance, Mahrhofer et al. suggest using autologous flaps for severe deformities and implants for moderate cases. The key concept is that *"like is replaced by like"*: muscle defects are often best addressed by muscle flaps, and volume deficits by fat or implants [5,6].

Technological advances, especially in 3D imaging and printing, are expanding options. Customized implants (titanium or polyethylene) can now be designed preoperatively from CT scans, reducing operative time and improving fit. Anderson et al.'s review of chest wall reconstruction supports that custom rigid prostheses and fixation devices yield superior mechanical stability [8]. In Poland syndrome, as in other chest defects, ensuring a rigid skeletal framework (while optimizing soft-tissue coverage) appears essential for good respiratory and cosmetic outcomes.

Conclusion

In pediatric Poland syndrome, a variety of surgical techniques have been successfully employed to correct chest wall and pectoral deformities. Muscle flaps (especially latissimus dorsi and gracilis) and fat grafting address soft-tissue volume, while tissue expanders and implants restore breast/chest shape. Rigid reconstruction with meshes, titanium bars, or custom 3D-printed implants is crucial when ribs or sternum are deficient. Most published series report stable chest walls and high patient satisfaction. A staged, multidisciplinary approach – often beginning in adolescence – is generally preferred to account for growth and to optimize cosmetic results. Continued innovation in bioengineered implants and minimally invasive techniques promises to further improve outcomes for these patients.

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