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## **Introduction**

Auricular surgery encompasses various kinds of surgical techniques given the initial defect. These defects can be congenital or acquired in nature. Further, acquired defects tend to either be secondary to trauma or malignancy. It is important for head and neck surgeons to have some knowledge of these techniques as these kinds of patients can be encountered in an otolaryngology practice. To this regard, knowledge of the anatomy, embryology, and aesthetic evaluation is paramount for an accurate diagnosis and appropriate surgical intervention of auricular deformities.

## **Anatomy and Embryology of the Auricle**

### **Embryology**

Ear development begins during weeks 5 to 6 of gestation with the formation of six mesenchymal swellings or hillocks. The anterior three hillocks and the posterior three hillocks originate from the first and second branchial arches, respectively. These hillocks are situated on either side of the first branchial groove and, with tissue growth and development, they fuse to form the auricle and its characteristic shape. The second arch gives rise to most of the anatomic landmarks of the ear including the helix, scapha, antihelix, antitragus, and the lobule. The first arch primarily gives rise to the tragus and the helical crus. Complete formation of the auricle occurs by week 8 of gestation.

### **Anatomy of the Ear**

An understanding of the topographic landmarks and structures of the normal ear and an assessment of what has been compromised will guide preoperative planning as to clear

identification of the defect and what surgical techniques will be necessary for correction of it. The auricle is a composite of skin and cartilage which, together, form folds and involutions that vary amongst all ears but still hold similar basic properties. The auricle contains elastic fibrocartilage which is essentially uniform throughout the ear in thickness. It is covered by skin on both surfaces. It is important to note that the anterior skin of the auricle is fine, thin, and closely adherent to the underlying cartilaginous framework. There is only a scant amount of subcutaneous fat anteriorly; however, a diffuse subdermal vascular plane is present and capable of supporting flap viability. The posterior surface is covered with less adherent skin that has two layers of fat as well as a larger subdermal plexus of nerves, arteries, and veins.

As mentioned, there are various convolutions of the auricle that can be identified in the normal ear. The helix is often described as the prominent rim of the auricle that terminates anteriorly in a helical crus that lies superior to the meatus of the external auditory canal. The antihelix runs interior to the helix and parallels it in course. It crowns the posterior conchal wall and also terminates in a crus that separates anteriorly into superior and inferior crura. There is a depression between the helix and antihelix called the scaphoid fossa and a depression between the inferior and superior crura called the triangular fossa. The tragus is a small, pointed prominence that sits anterolateral to the external auditory canal. It has a posterolateral counterpart called the antitragus. Within the interior floor of the auricle arises a cavity known as the conchal bowl which is about 8mm deep to the tragus and antitragus. This cavity is divided by the anterior helical crus to form the superior cymba concha and the inferior cavum concha. Extending inferiorly is the lobule, which is devoid of the cartilaginous skeleton.

### **Vascular Supply**

The arterial blood supply of the ear originates from the superficial temporal and posterior auricular arteries with some contributions from the occipital arteries. The superficial temporal artery arises anterior to the ear and gives off a superior, medial, and inferior branch that supplies the anterior and anterolateral aspect of the auricle. The posterior auricular artery travels parallel to the post-auricular sulcus and predominantly supplies the posterior auricular surface. The end branches of these arteries extensively anastomose to form a tremendous blood supply that allows for several surgical approaches to the ear. The venous drainage is complementary to the arterial supply and empties into the external jugular vein.

### **Neurologic Supply**

The sensory supply to the auricle consists of four nerves. The primary nerve supply is the greater auricular nerve of C2 - C3 which supplies the inferior surfaces of the auricle. It is an important surgical landmark as it travels 8mm posterior to the post-auricular sulcus and can cause significant anesthesia to the ear if damaged. Conversely, regional anesthesia to the auricle can be readily accomplished by instilling anesthetic along its base anteriorly and posteriorly. The lesser occipital nerve from the ventral rami of C2 and C3 supplies the cranial surface or posterior superior surface of auricle. The auriculotemporal nerve of the mandibular branch of CN V supplies the anterior surface of the auricle. Lastly, the conchal bowl and the tragus are supplied by Arnold's nerve, which is a distal branch of the vagus nerve.

The auricle has 6 clinically insignificant intrinsic muscles that are supplied motor innervations by the facial nerve. These muscles are the major and minor helices, tragus, antitragus, transverse, and oblique muscles. Additionally, there are three extrinsic muscles also supplied by CN7 which are the anterior, superior, and posterior auricularis muscles.

## **Aesthetic Evaluation of the Ear**

Aesthetic evaluation of the ear is important for preoperative planning and should be documented with standard preoperative photography. This photography includes a frontal view, right and left lateral views, and right and left oblique views along with close up left lateral and right lateral views.

### **Auricular Measurements**

About 85- 90% of ear growth is achieved by 5-6 years of age. Although ear height growth continues into adulthood, the width and distance of the ear from the scalp rarely change after the age of 10. The average ear is 65mm long and 35mm wide. The ear width is 50-60% of the height. On the lateral view, the superior aspect of the helix lies at the level of the lateral eyebrow (superior orbital rim). The inferior aspect lies at the level of the base of the nasal alae (nasal spine). The ear is situated roughly 6 cm from the lateral orbital rim and slopes 15-20° posteriorly from the vertical axis to approximate the nasal dorsum within 15°. The auriculocephalic angle, the angle between the auricle and the scalp, is most important in the posterior view of the auricle. It is set by a combination of the angle of the posterior wall of the conchal bowl (90°) and scapha-conchal angle formed by the antihelical fold (90°) and should be 20-30° in measurement. The distance between the helical rim and the scalp should be slightly less than 2cm with this angle. On the frontal view, the helical rim should be seen lateral to the lateral most exposure of the antihelix.

### **Cultural differences**

There are variations to these measurements especially amongst sex and races. The average Caucasian female ear is 59mm and 32.5mm for height and width, respectively. In persons of African descent, the auricle length tends to be shorter versus persons of Asian descent who tend to have slightly longer ears.

### **Congenital Auricular defects**

#### **Congenital**

Congenital malformations to the external ear range from deformities of the pinna, including auricular atresia to stenosis of the external auditory canal. These abnormalities include microtia and prominauris (prominent ears) as well as the lesser discussed deformities such as lop ear (folding of the top portion of the auricle down and forward, reminiscent of the lop eared bunny), cup ear (a prominent ear with a lop deformity plus an enlarged concha bowl), Stahl's ear (abnormal "third crus" traversing the upper pole of the scapha leading to the appearance of a pointed ear, often called "Spock ears"), and cryptotia (an appearance of a partially buried ear). These congenital anomalies may occur as a result of genetics or be secondary to environmental

exposures. The list of syndromes associated with these deformities is extensive and include Goldenhar, Treacher Collins, and brancio-oto-renal syndromes; thus, their presence should prompt a complete head and neck examination to rule out other congenital abnormalities.

## **Prominauris**

Prominauris is one of the most common congenital defects that occur in 5% of the population. It is autosomal dominant in inheritance and is described as a protrusion of the auricle greater than the normal auriculocephalic angle ( $> 30\text{-}40^\circ$ ). It is known to be a function of one or a combination of the following defects: a poorly developed antihelical fold (most common) or formation of excessive conchal cartilage (next common). Poor development of the antihelix leads to no definition between the conchal cavity and the scaphoid fossa resulting in lateral projection of the upper portion of the helix. Excessive conchal cartilage leads to significant protrusion of the auricle. To a much lesser extent, a protruding ear lobe, irregularities along the helix, or anteromedial displacement of the insertion of the post-auricular muscle can contribute to the development of prominauris. Precise recognition of the specific defect causing prominauris is paramount preoperatively as it will guide surgical technique.

Prominauris has a well documented psychological influence. Studies comparing data before and after corrective surgery for prominent ears reveal improved QOL, improvements of self esteem, decreased psychosocial anxiety, and decreased anxiety states, specifically in children. As school-aged children are more likely to suffer the psychological consequences of peer ridicule, it is recommended that the ideal age for surgical correction, or otoplasty, should occur between the ages of 5-6 years. Further, at this age, children are about to or have recently started attending school and are able to participate in their own postoperative care.

## **Acquired Auricular defects**

Acquired defects of the auricle include those that result from trauma and iatrogenic defects resulting from surgical excision specifically with cutaneous malignancies and the resulting defect after Moh's surgery.

### **Trauma**

Given the superficial location of the auricle, it is vulnerable to traumatic injury. These include varying degrees of lacerations and injuries from falls, animal bites, car accidents, and sports. In one case series from 1983, human bites were found to be the most common cause of traumatic auricular injury [1]. A more recent case series found car accidents to be the most common cause of injury [13]. Trauma from burn injury offers a unique challenge. Successful reconstruction of the ear after burn injury depends on the extent of the burn injury and availability of unscarred, healthy tissue to achieve an appropriate construct. However, often times, given the extent of burn injury, this reconstruction is limited by a scarcity of supple, elastic skin and fascia. Soft tissue lost post injury should be classified into the number of tissue layers lost and the area the ear affected as this will guide surgical repair options.

## **Moh's microsurgery**

Of the non-melanoma skin malignancies, basal cell carcinoma accounts for 21% of neoplasms of the external ear and temporal bone. In the auricle, BCC accounts for 45-90% of malignancies and SCC for 10% of malignancies. The recurrence rates of BCC and SCC are 1 and 5%, respectively. Indications for Moh's surgery include: recurrent or incompletely excised basal cell carcinoma (BCC), squamous cell carcinoma (SCC), lesions located in high-risk areas or embryonic fusion planes such as the eyelids, nose, ear, nasolabial folds, upper lip, vermilion border, columella, periorbital, temples, preauricular and post-auricular areas. Other indications are: clinically and histologically aggressive tumors, tumors in cosmetically or functionally important areas, tumors arising in sites of previous radiation, and tumors in patients with basal cell nevus syndrome. Moh's is particularly useful for recurrent BCC greater than 2cm. Moh's surgery involves gross curettage of tissue followed by excision of the thin tissue planes with identification of residual tumor using light microscopy. This is done until clear margins are obtained. Processing of the tumor in this manner leaves a fresh tissue defect enabling immediate reconstruction after complete removal of disease.

## **Otoplasty**

Otoplasty is the term used to describe surgical techniques for correction of prominauris. Diffenbach first described a technique for surgical correction of prominauris in 1845 and since its origin, several techniques have developed but the goals of otoplasty, as described by McDowell in 1968 remain the same; protrusion in the upper third of the ear should be eliminated, the helix of both ears should be seen lateral to the antihelix from the front view (failure to do so results in "hidden helix"), the helix should have a smooth and regular contour, the post-auricular sulcus should not be markedly decreased or disturbed, the ear should not be placed too close to the head (especially in males), and the contours and positions of the two ears should match closely but not be symmetrical.

Today, surgical techniques are divided into cartilage sparing versus cartilage manipulating techniques and those that correct the absent antihelical fold or reduce the excessive conchal bowl. In 1963, Mustarde first described a cartilage-manipulating technique that restored the antihelical fold using permanent conchoscaphal horizontal mattress suture; in 1968, Furnas described a conchal setback technique using permanent conchomastoidal sutures. Today, these techniques, with some variability based on surgeon, are most commonly used in correction of prominauris secondary to an absent antihelix, excessive conchal cartilage, or a combination thereof.

### **Technique of Mustarde**

This technique was first described in 1959 by Mustarde as a form of correction of prominauris secondary to a poorly formed antihelical fold. This cartilage manipulating technique uses strategically placed permanent sutures to reform an antihelical fold. This procedure is done under general anesthesia and perioperative broad spectrum antibiotics are administered. Antihelical fold markings are created on the anterior helix. This is done by exerting gentle pressure on the auricle to fold the scapha back against the underlying scalp to create a projected antihelical fold. The crest of this fold is marked with a surgical marker. With

the Mustarde technique, through-and-through markings with a hypodermic needle and methylene blue (one source reports using India ink) roughly 7mm on either side of the marked antihelical fold are made. The purpose is of this is to guide suture placement on the posterior aspect of the auricle. The projected antihelix is then injected with 1% lidocaine with 1/100,000 epinephrine to assist with hydrodissection, freeing the skin from the underlying cartilage.

A fusiform post-auricular skin incision is created. Per Lalwani, it is best to excise more skin from the post-auricular surface than the mastoid surface in attempts to better conceal the scar in the post-auricular sulcus. The purpose of excising this ellipse of skin is to remove the predicted skin excess that results once the ear is repositioned. Once this fusiform of skin is excised, the posterior skin is elevated from the perichondrium over the helix, antihelix, and conchal cartilage.

Once the posterior aspect has been addressed, the anterior aspect should be addressed before suture placement. As the anterior skin is tightly adherent and hydrodissection from infiltration with local injection is not fully adequate to release the anterior skin, an instrument needs to be introduced into the anterior surface of the ear to release the skin and allow for access to the anterior cartilage for scoring through the perichondrium. Access to the ear is done by creating an access point or "slot" at the tail of the helix posteriorly. Once this is done, access to the anterior surface of the ear is possible and a tunnel over the projected antihelical fold is created (can be done with fine scissors or a Freer elevator). With the Mustarde technique, the cartilage in this area needs to be weakened to allow for pliability as the fold is created. An abrading tool (otoabrader, nasal rasp, Adson-Brown forceps, dermabrader with a small diamond fraise, etc) is passed into this tunnel and several gentle pass with the tool is used to weaken the cartilage. Care should be taken not to over-abrade the cartilage (ie: full thickness cartilage scoring) as this can lead to a sharp-edged antihelix.

Securing of the antihelical fold is done with permanent suture (4-0 Mersilene). Horizontal mattress sutures are placed in the posterior surface from medial perichondrium through cartilage and lateral perichondrium. Extreme care should be taken not to pierce the anterior skin. The sutures should be placed perpendicular to the demarcated antihelical fold so when they are tightened a well-rounded antihelical fold is created. Further, they should be parallel to the helix at the lateral extent of the antihelical fold, as the helix and antihelix run parallel in fashion.

Once complete, the wound should be irrigated and the post-auricular incision should be closed with absorbable suture. Of note, a tension free closure is paramount in this location as it is highly prone to keloid formation. The dressing is important to prevent hematoma formation and it must provide adequate pressure to obliterate any dead space. Pressure facial dressing or mastoid dressings have been suggested with petroleum gauze or antibiotic ointment gauze/cotton applied directly to the ear.

### **Technique of Furnas**

This technique was first described in 1969 by Furnas as a solution to excessive conchal cartilage seen with prominauris and is often done in adjunct with the Mustarde technique. A fusiform post-auricular skin incision is delineated and then infiltrated with local injection. The width of the incision can be estimated by manually pushing the concha toward the mastoid to determine the appropriate amount of setback and where wound closure should be. The skin is

excised (including the underlying soft tissue and muscle) and the posterior skin over the helix, antihelix, and concha are undermined and elevated to assist in suture placement.

Three to four permanent horizontal mattress sutures (3 or 4-0 Mersilene) are then placed from the lateral third of the concha cavum and cymba (parallel with the natural auricular curvature) through the cartilage and lateral perichondrium to the mastoid periosteum. Extreme care is taken to not pierce the anterior conchal skin in the process. When these sutures are tightened, what was once the wall of the concha will be converted into a longer conchal floor. Again, tension-free closure of the post-auricular incision is important to prevent keloid formation.

## **Principles of Auricular Reconstruction**

### **Secondary Intention**

This is an ideal option for patients who have had previous radiation therapy, are smokers, diabetics, have coagulation disorders, or some other form of microvascular compromise and are poor candidates for grafting to this area as compromise of flap circulation is a concern. Patients who have medical conditions that prohibit surgery and have absolute contraindications to primary repair are also prime candidates for this technique. Defects in the concavities of the ear (ie: conchal bowl and triangular fossa) are ideal as these defects heal well and leave a nearly imperceptible scar. Defects on the antihelix, a flat area of the ear, can also be amendable to secondary intention with fair result as long as there is underlying cartilage support. Secondary intention is not ideal for defects of the convex areas of the ear, specifically the helix, as these result in permanent and obvious notching.

Assessing wound size, skin color, and depth help to determine cosmetic outcome of secondary intention healing. Smaller defects (1cm or less) heal better than larger ones and form smaller scars when they contract that blend with other skin imperfections. Size of the defect is especially important in darker or telangiectatic skin as scar tends to be hypopigmented, thus making a larger scar more noticeable. Likewise, more superficial wounds heal better than deeper wounds in the same area.

One concern of healing by secondary intention is a protracted course of healing. This can take several weeks depending on the size of the defect and can be challenged by a lack of tissue laxity and, given the poor vascularity of cartilage, presence of exposed cartilage (lacking overlying perichondrium) in the defect. In the case of cartilage exposure, healing can be aided by fenestrating the exposed cartilage thereby exposing it to the vascular-rich dermis of the posterior auricular skin.

Daily wound care is important and can be viewed, by some, as a down-fall to this method. The goal is to prevent crusting and drying of the wound that can delay healing, worsens scar formation, and de-epithelize areas of new epithelization with debridement of crusting or removal of dry or adherent dressing. Daily dressing changes with an antibacterial ointment applied to the surface is recommended.

## **Full thickness skin grafts (FTSG)/ Split thickness skin grafts (STSG)**

Skin grafting is, to some, a preferred option for defects of the conchal bowl and antihelix that are generally < 2.0cm in size. A FTSG is often preferred over a STSG as it tends to be a better color match for defects in the auricle and has a lower potential for contracture. FTSG can be harvested from the contralateral pre or post-auricular skin or the supraclavicular area. FTSG is a better match than STSG not just for color, but texture and thickness. Of concern is grafting over areas of exposed cartilage. It is recommended that areas of conchal cartilage should be excised to allow for well-vascularized area for the graft. Excising this cartilage should not compromise the overall integrity of the structural support of the auricle.

## **Post-auricular Island Flap or “Flip flop flap”**

This technique was first described by Masson in 1972 in plastic surgery literature. It has been traditionally used for defects of the anterior conchal cartilage but has been performed by some for defects of the scaphoid fossa and antihelix. It is a fasciocutaneous flap vs myocutaneous transpositional flap that involves pedicled post-auricular skin as a cover for anterior auricular defects. It is believed that the post-auricular muscle and fascia are incorporated into this flap and perforators from the post-auricular artery supply this area. Defects corrected with this method are usually 2cm or less in size.

To execute this flap, a template is made of the defect and the auricle is reflected anteriorly to mark the donor site (post-auricular skin including the post-auricular sulcus). This post-auricular flap is incised, forming an island of skin with a subcutaneous pedicle. A slit incision is begun at that posterior aspect of the defect and carried to the post-auricular sulcus creating a through-and-through defect for passage of the flap from posterior to anterior. This incision is extended to the base of the flap and undermining is then carried out in the plane of the mastoid periosteum. Once this is complete, the flap and its pedicle are pulled through the incision and laid on the anterior defect and this is closed with fine nonabsorbable sutures. The secondary post-auricular defect is closed primarily.

## **Antia Buch chondrocutaneous advancement flap**

This flap, first described in 1967 by Antia and Buch, is used for reconstruction of helical defects of 3 cm diameter or less. In this method, the anterior skin and cartilage are incised at the base of the helical rim forming chondrocutaneous flaps. The posterior skin is not incised; rather the post auricular skin is elevated from the perichondrium and serves as a vascular pedicle and preserves the blood supply to the helical rim. The chondrocutaneous flaps are raised unilaterally or bilaterally (depending on the defect). Once raised, the ends of these helical margins are re-approximated (directly brought together). Posterior standing cone deformities formed are corrected with Burrow’s triangles. Auricular height will undoubtedly be decreased with this technique as the length of the repaired defect will have been transferred to the pulled-up lobule. If the discrepancy between both ears is marked, then the contralateral ear may need to be augmented with a wedge excision and closure.

## **Bipedicled “tubed” flap**

This flap is used for longer helical rim defects >2.5cm in size. It can be based in the pre, post, or retro-auricular skin, depending on the location of the helical defect. It is traditionally a three-staged process and begins with raising a bipedicled, tube shaped flap. This flap is adhered over the defect with its pedicles intact. The underlying secondary defect at the donor site is closed primarily. Stage two and three involve separation of one pedicle and inseting it into the defect and each is done 3 weeks apart.

## **Banner transpositional flap**

This is a supra- or pre-auricular based flap that can be used to cover the helical root (proximal helix) or superior helical rim. Defects of the helical root can be covered in a single staged fashion. Essentially, a flap is raised in the pre-auricular skin with its base contiguous with the defect. It is then secured to the defect and the secondary defect is closed primarily. For defects of the superior helical rim, double banner flaps are employed. One is elevated in the pre-auricular skin, the other in the supra-auricular skin, and both share an anterior pedicle. This is a two-staged process. Both flaps are elevated and secured to the anterior and posterior aspects of the helical rim defect. The pedicle is divided three weeks later.

## **Mladik Pocket Principle**

This staged principle was first described by Mladik et al in 1971 and is used for reattachment of partial avulsions of the ear lobe, assuming the avulsed portion has salvageable cartilage. As an aside, when transporting the avulsed auricle for repair, it should be placed in saline or water and then be placed in ice. Do not place it in ice directly as this can lead to severe frostbite, possibly rendering it useless. In the first stage, the amputated auricle is de-epithelialized and the amputation stump is reattached, and then buried in a retro-auricular subcutaneous skin pocket. This pocket is created by incising and raising a flap in the retro-auricular/occipital skin. The posterior skin edge of the auricle is then sutured to the adjacent occipital skin incision while the flap remains elevated. The de-epithelialized cartilage is secured in this pocket by reattaching the cartilage stump, and the overlying skin flap is replaced over the cartilage and sutured to the anterior skin edge of the auricle. Three to eight weeks later, the ear is elevated and the posterior aspect is skin grafted if not already re-epithelialized.

## **Double lobed flap**

An absent lobule can be reconstructed using this anteriorly-based auriculomastoid flap. A bilobed shaped flap is delineated on the auriculomastoid skin and raised with its base functioning as the anterior attachment of the neo-lobule. The neo-lobule is formed when the raised flap is folded in on itself and attached the superior auricle. The secondary defect is closed primarily.

## **Complications**

Complications for auricular surgery can be divided into early (occurs 24-96 hours) and late complications including aesthetic complications based on procedure. Hematoma is one feared early complication as it can lead to skin and/or cartilage necrosis with ear disfigurement. A

compliant of ear tightness or pain should prompt inspection of the ear. This complication can be prevented establishing adequate hemostasis intraoperatively and using pressure dressings postoperatively.

Infection, evidenced by pain/tenderness and signs of inflammation, usually occurs by day three or four. Treatment should be prompt to avoid suppurative chondritis and consists of systemic antibiotics with coverage for staphylococci, streptococci, and *Pseudomonas aeruginosa*. Chondritis is heralded by signs of obvious infection including severe edema and pain. Treatment will require empiric IV antibiotics, drainage, debridement, and a wound culture to target therapy.

Other early complications include suture extrusion, which is of particular concern with otoplasty (can also be a late complication along with suture granuloma). Skin necrosis is another complication resulting from vascular compromise due to pressure necrosis (excessively tightened sutures or tight ear dressings) or inappropriately undermined skin flaps (too superficial). Over-tightened sutures and ear dressings should be avoided. Skin necrosis can be treated reducing pressure over the skin and applying antibiotic topical cream. Similarly, venous congestion of flaps arises because the venous outflow is compromise by clot formation or venous compression. Treatment includes hyperbaric oxygen, removal of obstructive sources, or medicinal leeches.

Examples of late complications include hypertrophic scar or keloid scar formation. These develop when the wound has healed and are a direct result from wound closure under tension. They are less common than other complications, however. Management of hypertrophic or keloid scars typically involves intralesional steroid injections. Management with excision alone has been shown to yield 45-100% recurrence rate. The best form of prevention is a tension free closure.

Aesthetic complications are also late complications that vary depending on the surgical technique employed. With otoplasty, some aesthetic complications include a sharp-edged antihelical fold (due to over-scoring of the cartilage) and hidden helix (the helix is position medial to the antihelix on a frontal view of the face). With otoplasty, telephone ear deformity (the upper and lower ear projecting more prominently than the middle ear) results from overcorrection of the middle third of the prominent ear. Reverse telephone ear deformity occurs when the mid-auricle protrudes after overcorrection of the upper and lower ear. Asymmetry between the left and right ear is a general complication of any technique as well as malpositioning, a close-fitting auricle, or a collapsed ear. Aesthetic complications are corrected with revision surgery.

## **Summary**

Auricular reconstructive surgery encompasses a variety of techniques for congenital and acquired defects. It is important for the surgeon to understand some of the prevalent techniques of surgical repair and have them in their arsenal of surgical repair options. Furthermore, it is my recommendation that the aforementioned techniques along with others be reviewed in conjunction with pictures/diagrams to obtain a complete understanding of the procedures.

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