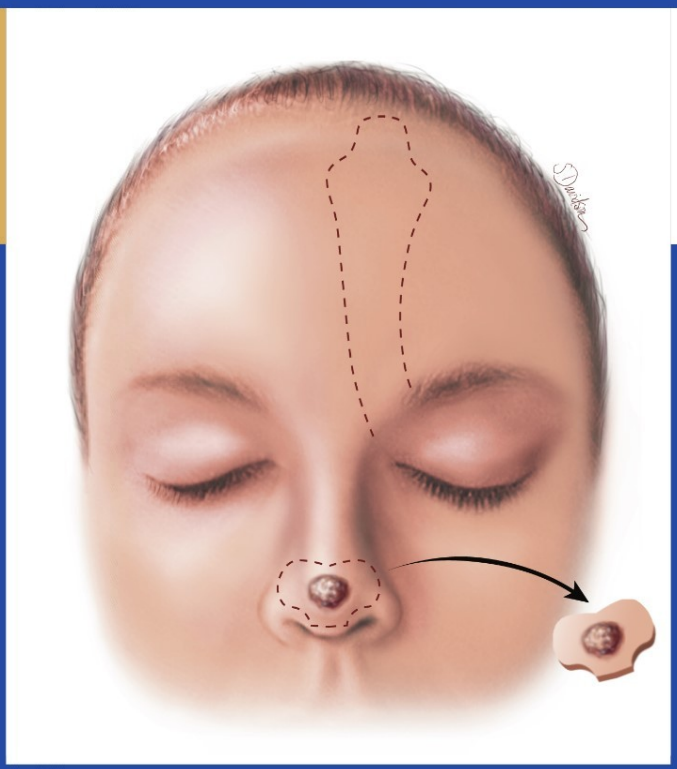
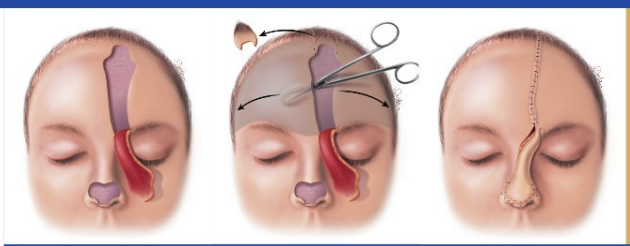
Shan R. Baker

Principles of Nasal Reconstruction





Second Edition

DVD-ROM INCLUDED

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To Catherine Belle Baker, Alexander Ray Baker, Monica Catherine Baker.
The essence of my life.

Acknowledgments

Although many people have indirectly contributed to the creation of this book, I would like to thank those who had major roles in assisting me in its preparation. Foremost, I am grateful to all of my patients who through their misfortune of being afflicted with skin cancer have enabled me to learn and perfect reconstructive surgical techniques. A particular gratitude is offered to those patients who have allowed me to publish their photographs in this book. I would like to thank Deborah DeGuire for assistance with preparation of the manuscript and Mary Hambright for her assistance with procuring photographs. I am grateful to Marcia Stuursma for her friendship, support, and serving as my ambassador to patients and colleagues over an interval that expands nearly my entire professional career. I am most grateful to Kathy Herman for her unfailing optimism, unflinching support, and never considering a task too great or too small to perform. Thank you for being such a successful liaison to my patients. A special thanks to James Bruce for his friendship. Mr. Bruce has assisted me for many years by preparing hundreds of photographs and video clips used in all of the lectures that I have prepared and books I have published over my career. I would like to thank Fred Bobrow for editing the DVD accompanying this book. I would to like to thank Timothy M. Johnson, M.D., Director of Dermatological Surgery at the University of Michigan and his colleagues Darius J. Karimipour, M.D., Timothy S. Wang, M.D., Christopher K. Bichakjian, M.D., Jennifer L. Schwartz, M.D., Sandra C. Paek, M.D., and Jeffrey S. Orringer, M.D. Thank you all for referral of your patients throughout the many years we have been professionally associated. Without your support and trust, this book would not have been possible. I would like to thank the many house officers of my department that assisted me with the filming of the surgical procedures appearing in the DVD. I would like to thank Sam Naficy, M.D., and Brian Jewett, M.D., for devoting many hours toward the preparation of their chapters. The quality of this textbook is directly related to your contributions.

Preface

This textbook provides an in-depth discussion of all aspects of nasal reconstruction. Like the first edition, it is designed to be a "working man's" manual for repair of cutaneous defects of the nose, providing practical and effective methods of reconstructing skin defects in a variety of sizes, configurations, and locations.

This is the second edition of a textbook published in 2002. Although the majority of the illustrations used in this edition are the same as those appearing in the first edition, the book is quite different. All of the chapters appearing in the first edition and included in this edition have been upgraded by introducing new concepts or additional information and most of these chapters have been lengthened. New chapters showing examples of complex nasal repair have been included in this edition. Most of the chapters in the book have been authored by myself. This is due to a conscious effort on my part to present personal surgical techniques and my philosophy of using local flaps in nasal reconstruction. Although this may have restricted the diversity of surgical approaches available for discussion, it enables a textbook with a more homogenous narrative and consistent message. Another major difference between the two editions is the inclusion of a DVD with the current work. The DVD demonstrates the design and transfer of a multitude of local flaps performed in the operating room. In addition to showing uncomplicated cases using simple cutaneous flaps, very complex defects requiring multiple flaps and grafts are included in the DVD.

This work represents the culmination of 32 years of cooperative interaction between me and the dermatological surgeons at the University of Michigan. During this interval, we have shared the care of a few thousand patients, which I believe was to the patient's benefit. This cooperative arrangement facilitated the interchange of knowledge and experience, which led to a hybrid of surgical approaches for the repair of nasal defects. This cross-fertilization of ideas was a direct benefit to me and my ability to care for patients and is the source of my desire to edit this textbook. This book would not have been possible without the cooperation of all of the dermatological surgeons in the Department of Dermatology at the University of Michigan. For this reason, I express my sincere gratitude to all of them for their continued support and confidence in me.

Shan R. Baker

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Part I

Fundamentals

History of Nasal Reconstruction

1

Brian S. Jewett and Shan R. Baker

Injury and disfigurement of the nose have been well described. Nasal deformity has been attributed to self-infliction, mutilation as a form of punishment, and various disease states. The first recorded account of mutilation as a form of punishment was in 1500 BC when, in India, Prince Lakshmana deliberately amputated the nose of Lady Surpunakha. King Ravana arranged for the reconstruction of Lady Surpunakha's nose by his physicians, documenting one of the earliest accounts of nasal reconstruction.[1] During the ninth century, Danes slit the noses of Irishmen who could not pay their taxes, and Sixtus Quintus of Rome mandated the amputation of the noses of thieves during the sixteenth century.[2] In 1769, the Ghoorka King of India ordered the amputation of the nose and lips of all 865 male inhabitants of the captured city of Kirtipoor, Nepal. The king changed the name of the city to Naskatapoor, which means "city without noses."[3] Traumatic amputation of the nose has been established in history as a form of humiliation to such an extent that the practice has insinuated itself into the language of many cultures in the form of idiomatic expressions. For example, in English, the phrase *to lose face* suggests humiliation or embarrassment. In Urdu and Punjabi, the phrase *mera noc kart gaya* is a common expression connoting "you have hurt my feelings," but it literally means "you have cut off my nose."[4]

The repair of nasal defects is the oldest form of facial reconstructive surgery,[5] and the Indian art of total nasal reconstruction represents the first, if not the most important, chapter in the history of plastic surgery.[4]

Early Nasal Reconstruction

The earliest descriptions of total nasal reconstruction come from ancient India during the Vedic period, approximately 3000 BC.[5] The first detailed description of nasal reconstruction is found in the Indian medical treatise *Sushruta Samhita* (700 BC). The operative procedure described was a cheek flap, and it was performed by members of a caste of potters known as Koomas.[6] Vagbhat, a fourth century Indian physician, recounts in greater detail the technique of cheek flap rhinoplasty. He describes the use of topical hemostatic agents, intranasal splints, and leaves. He emphasizes cutting with accuracy, protecting the pedicle, and approximating the edges of the wound carefully.[1] Most of the reconstructions were performed by potters and bricklayers, and advances were made as the tradition was passed down among family members. Surgical equipment included special cements, cotton suture, and ant heads to close wounds.[4]

The first European to record techniques of repairing defects of the nose, lips, and ears by using adjacent tissues was Celsus during the first century AD.[7] Paulus Aegineta, a seventh century Greek physician, helped to integrate Eastern medical and surgical practices into Western civilization. He summarized contemporary medical practices in a seven-volume compendium. In the sixth book of the set, he describes the treatment of facial defects by the rearrangement of adjacent healthy tissue.[4]

The Italian Method

In fourteenth century Italy, Branca de Branca performed a procedure similar to that described in *Sushruta Samhita*.[8,9] His son, Antonius Branca, went on to describe a new method of nasal reconstruction: the Italian method. This procedure involved transferring a piece of tissue from the arm to the nose in a staged fashion. The operation was tedious, required six stages, and remained a secret within the Branca family. The only contemporary medical text with an accurate report of Branca's procedure is the *Buch der Buendth-Ertznei (The Book of Bandage Treatment)*, written in 1460 by Heinrich von Pfolspeundt, a knight of the Teutonic Order. The book remained unknown for more than 400 years, hidden in manuscript form in the library of Erfurt University. In the second half of the nineteenth century, Haeser and Middledorpf discovered it and had it published.[10]

Alessandro Benedetti, professor of anatomy and surgery at Padua University in Italy, was the first to publish results using the Italian method (Fig. 1.1). His publication appeared before Haeser and Middledorpf's book

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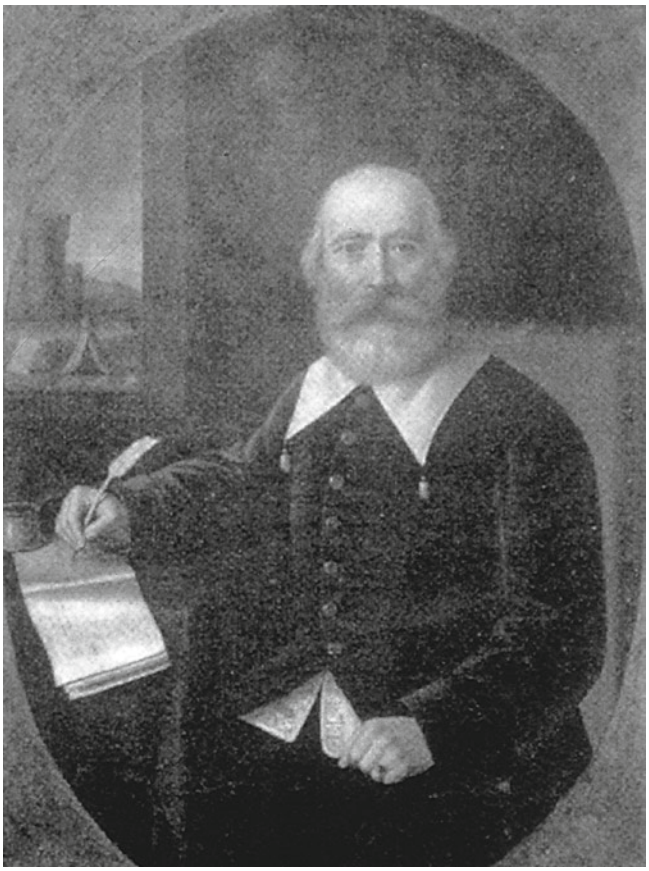

Fig. 1.1 Portrait Alessandro Benedetti, Legnago, Italy

containing the original description by Antonius Branca. Benedetti rebelled against the Greek traditions of teaching anatomy as a blend of science and magic, and emphasized teaching through direct observation of facts, with independence of judgment. Benedetti published an eight-volume text on anatomy in 1493. In Vol. IV, Chap. 39, he describes the Italian method of nasal reconstruction[11]:

> *At present ingenious men have indicated how to correct nasal deformities. Their method consists in cutting a little piece of flesh from the patient's arm, in the shape of a nose and applying it to the stump. For this they cut the top layer of skin on the arm with a scalpel. Having made a scarification in the nose, if this is needed, or if the nose has been recently cut off, they bind the arm to the head, so that raw surface adheres to raw surface. When the wounds have conglutinated together they take from the arm with a scalpel as much as is needed for the restoration. Blood vessels of the nose supply nourishment to the flap, and finally a covering is obtained, with hairs sometimes growing there after the nature of the arm.*

More than 100 years later, in 1597, Tagliacozzi published *De Curtorum Chirurgia per Insitionem*, which described in detail the Italian method of nasal reconstruction (Fig. 1.2). This was the first text dedicated solely to the subject of plastic surgery. Tagliacozzi reproduced Benedetti's passage in Vol. I, Chap. 19, of his work.[12]

Fig. 1.2 The Italian Method. (From Nichter et al.[4])

The Indian Method

The origin of using a forehead flap for nasal reconstruction is unclear in history, but the procedure has been performed since 1440 AD by the Mahrattas of Kumar, some Nepalese families, and the Kanghiara family of Kangra, India. The procedure was practiced in secrecy, shared among family members, and it became known as the Indian method.[1,5]

The first account of the midline forehead flap is found in the *Madras Gazette*, a journal published in Bombay during the 1700s. The article was later reproduced in English in London's *Gentleman's Magazine* (1794), and it fostered the renaissance of nasal reconstructive surgery in Europe.[4] The article describes the fate of Cowasjee, a bullock driver with the English army in the War of 1792. Cowasjee had been captured by Tipu Sultan, ruler of Mysore, who violently opposed British involvement in southern India. Tipu Sultan cut off food and supplies to the English troops under the command of Cornwallis by attacking the Maharatta bullock

drivers who transported needed grains to the British. The Sultan gave rewards for each nose or ear brought back after a raid. Cowasjee lost his hand and nose, and the article describes the operation to restore his nose. The article is signed "B.L.," but the author is assumed to be an English surgeon named Cully Lyon Lucas (Fig. 1.3). The operation was described as follows:

> *A thin plate of wax is fitted to the stump of the nose, so as to make it a nose of good appearance. It is then flattened and laid on the forehead. A line is drawn around the wax, and the operator then dissects off as much skin as it covered, leaving undivided a small slit between the eyes. This slit preserves the circulation until a union has taken place between the new and old parts.... Skin is now brought down from the forehead and, being twisted half round, its edge is inserted into the incision, so that a nose is formed with a double hold above, and with its alae and septum below fixed in the incision. A little Terra Japonica is softened with water, and being spread on slips of cloth, five or six of these are placed over each other, to secure the joining. No other dressing but this cement is used for four days.... The connecting slips of skin are divided about the twenty-fifth day.... The artificial nose is secure and looks nearly as well as the natural one; nor is the scar on the forehead very observable after a length of time.*

Fig. 1.3 English bullock driver after total nasal reconstruction, as shown in Letter to Editor, London's *Gentlemans Magazine,* 1794. (From Nichter et al.[4])

Fig. 1.4 Joseph Carpue (1764–1840), the first European to perform the Indian method of nasal reconstruction. (From Nichter et al.[4])

The English surgeon Carpue learned the procedure and published a book in 1816 called *An Account of Two Successful Operations for Restoring a Lost Nose from Integuments of the Forehead*. His detailed description states that the procedure was performed with "an old razor," and lasted about an hour and a half (Fig. 1.4).[13] As Carpue's book circulated throughout Europe, the operation came to be more widely accepted.[14] In 1818, the first book devoted solely to rhinoplasty, *Rhinoplastik*, was published by Carl von Graefe. The book listed 55 articles and books on the subject of rhinoplasty and included Carpue's work.[4] Waren was the first to perform the forehead flap operation in America, and he published his account in the *Boston Medical and Surgical Journal* in 1837.[15]

Internal Lining

As the use of the midline forehead flap became more widespread, it became apparent that the results of reconstructing full-thickness defects without supplying an internal lining

were poor. The shape of the nose often became distorted because the skin flap used for reconstruction contracted during the healing process. This was due to the exposed undersurface of the flap. Suggested sources for internal lining when reconstructing full thickness nasal defects includes skin grafts, nasal mucosa, local flaps, and folding the forehead flap on itself.[16]

During the nineteenth century, Ernst Blasius, chief of ophthalmologic surgery of Berlin, Johann Friedereich Dieffenback, chief of surgery at Munich Hospital, and Natale Petrali of Milan advocated folding the midline forehead flap on itself to provide both external coverage and internal lining. All three surgeons claimed precedence in succeeding with this method of total nasal reconstruction. Based on the date of the first operation to use a folded forehead flap for total nasal reconstruction, the honor goes to Blasius, who performed the procedure in 1838 (Fig. 1.5). Petrali was the first to actually publish an account of this method of reconstruction, in 1842. However, the idea of folding a forehead flap on itself when restoring the lower part of the nose was first suggested by Pierre August Labat of Paris. In 1834, he described using a trilobed forehead flap and turned one of the lobes inward for internal nasal lining. Because these surgeons were associated with large teaching hospitals in Europe, the use of midforehead flaps grew in popularity.[8,17–19]

Using a forehead flap to supply tissue for the internal lining increased the size of the flap required for reconstruction. As flaps increased in size, it became more difficult to pivot the flap 180° in the midline. The awkward but necessary twisting of the flap often compromised the flap's blood supply and made it difficult for the flap to reach the columella. In addition, taking more forehead tissue left large donor-site scars that were unsightly. In 1850, Auvert suggested slanting the flap in an oblique fashion, diagonally across the forehead toward the temporal area. This design provided sufficient length to reach the columella while still allowing the flap to fold on itself. In 1935, Gillies proposed using a design called the up-and-down flap. The pedicle ascended from the origin of the supraorbital vessels on one side and extended to the hair-bearing scalp. The flap then turned downward in an arc to the contralateral supraorbital vessels (Fig. 1.6). Converse, in 1942, described a scalping flap with a longer pedicle that reached to the hair-bearing scalp. This flap left the patient with a hairy pedicle across the eye for weeks prior to division. Ultimately, these flaps caused the patient to live with a large donor-site scar. Patients also experienced significant nasal obstruction secondary to the bulkiness of the tissue, once the forehead flap was folded on itself to provide the lining for the nose.[8]

Other modifications in the design of forehead flaps included extending one limb of the incision inferior to the other, as described by Lisfranc in 1827. Labat curved his incisions proximally, centering the flap over the medial brow and canthus on one side. Both of these modified designs reduced the twist of the pedicle base and brought the flap closer to the recipient site.[9] During the 1930s, Kazanjian was the first to delineate the primary blood supply of the midline forehead flap. He described a precise midline forehead flap that facilitated primary closure of the donor-site wound. This was a major advance in the field, given concerns about the forehead scar that developed after the healing of the site by secondary intention.[20] Kazanjian and Converse illustrated that a gap exists between the paired frontalis muscles, so no compromise of forehead musculature occurs with harvesting of the midline forehead flap.[21] In the 1960s, Millard designed the seagull flap, with lateral extensions for reconstruction of the alae. The extensions were designed to follow the natural

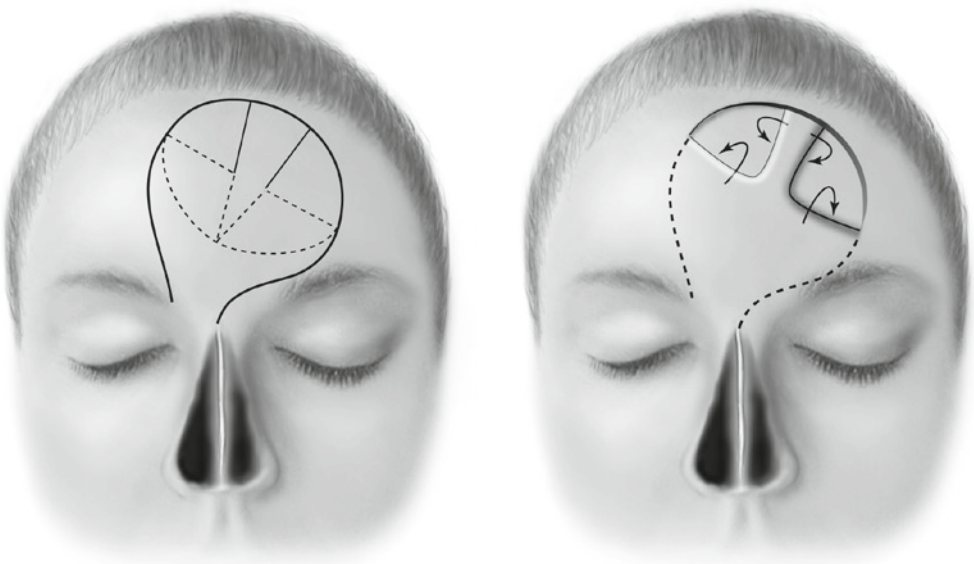

Fig. 1.5 Blasius procedure (1848) for total nasal reconstruction with oval folded flap technique (after Nelaton and Ombredanne, 1904)

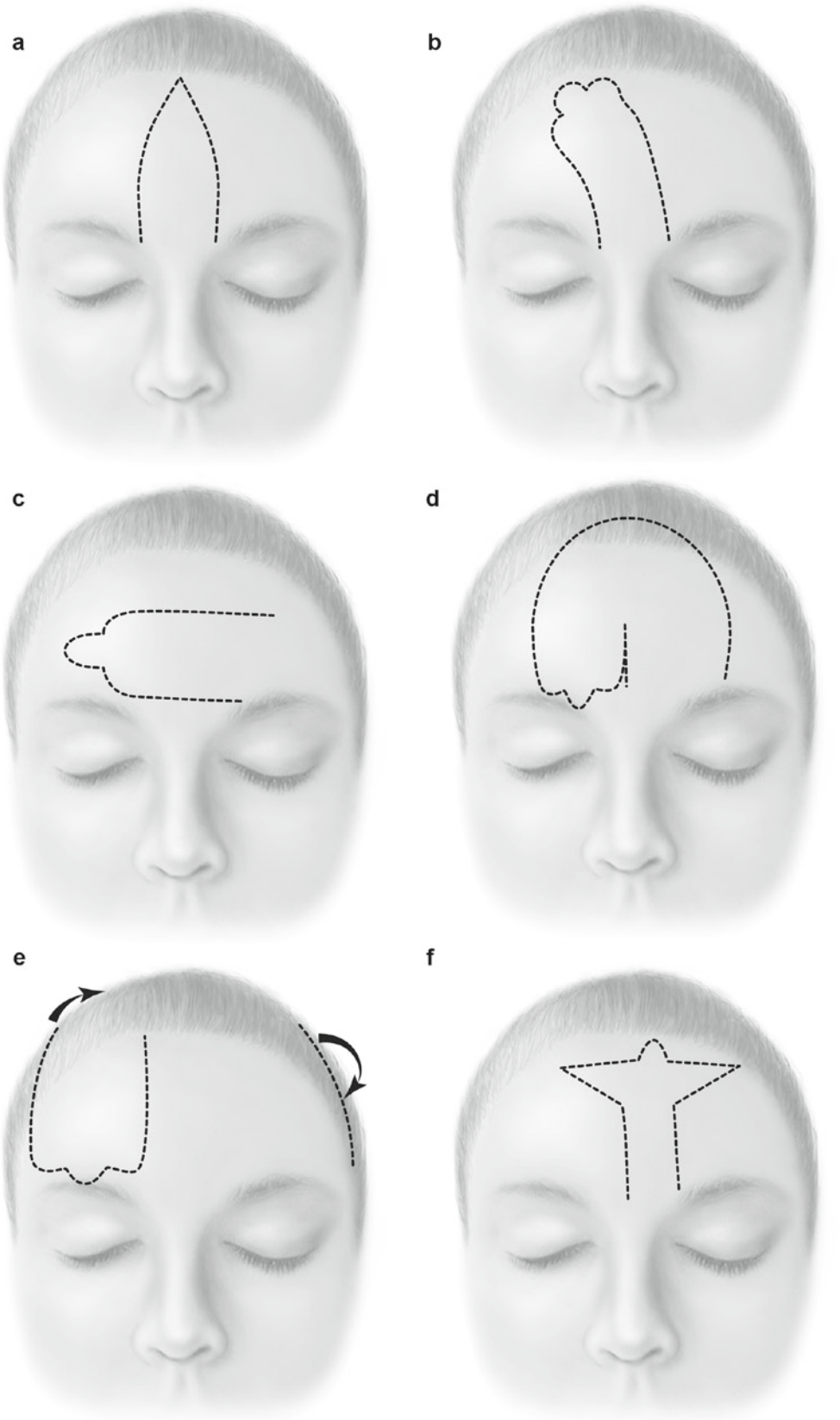

Fig. 1.6 Forehead flap designs. (**a**) Indian median flap. (**b**) Oblique flap. (**c**) Horizontal flap. (**d**) Gillies' up-and-down flap. (**e**) Converse's scalping flap. (**f**) Millard's gull-winged paramedian forehead flap

creases of forehead wrinkle lines. Incisions for the flap extended below the level of the supraorbital rims to gain extra length and ease of pivoting.[22–24]

While some surgeons were experimenting with larger forehead flaps that could be folded to provide lining, others were exploring the use of adjacent facial tissue as a source for internal lining. In 1874, Volkmann described turning inward portions of residual nasal skin adjacent to the defect to provide internal lining (Fig. 1.7). Thiersch, in 1879, described the transfer of cheek flaps to the nose for internal lining (Fig. 1.8). In 1898, Lossen first applied skin grafts to line the forehead flap. The grafts were placed under the forehead musculature, allowed to heal, and then transferred to the nose as a composite flap. Millard advocated bilateral, superiorly based, hinge melolabial flaps to line the alae and columella.[8] Converse and Casson, in 1969, used a forehead flap for the internal lining and flaps from other donor sites to cover the external nose.[25] Despite the use of adjacent tissue and skin grafts for lining, patients continued to have difficulty with nasal obstruction. This was due to scar contracture and failure to provide sufficient structural support to the nose. Attempts were made to use cartilage grafts to replace missing nasal framework at the time of forehead flap transfer, but these procedures were often complicated by extrusion or necrosis of the grafts. Insertion of cartilage grafts secondarily was also problematic and often provided little

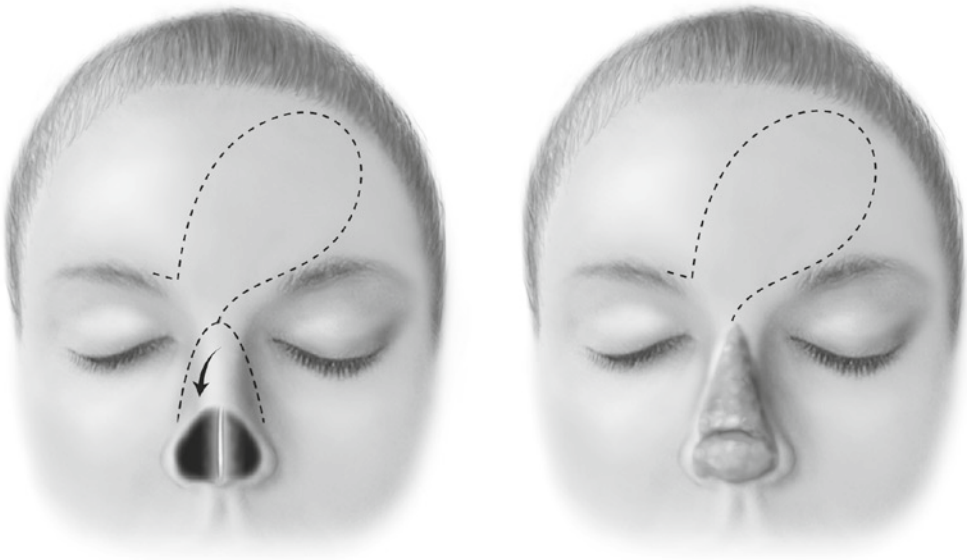

Fig. 1.7 Volkmann's procedure (1874) for total nasal reconstruction with lining created from remaining nasal skin plus forehead flap for external covering (after Nelaton and Ombredanne, 1904)

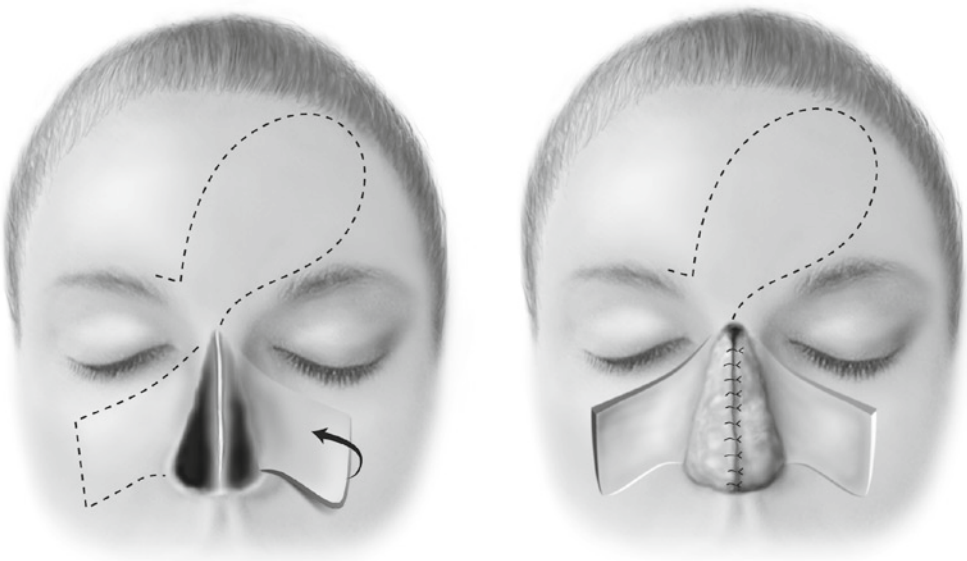

Fig. 1.8 Thiersch's procedure (1879) for total nasal reconstruction with lining created from the cheeks, plus forehead flap used for external covering (after Nelaton and Ombredanne, 1904)

improvement in nasal contour because of contracture of the covering flap.

Surgeons looked to the native nasal mucosa for internal lining. In 1902, de Quervain first used the septum to provide lining and support for the lateral wall of the nose.[26] Kazanjian described a septal flap based on the dorsum. The flap consisted of contralateral mucoperichondrium and was used to line the ala.[21] Gilles described a mucoperichondrial flap based on the caudal septum.[27] Millard described a superiorly based septal flap that was used to reconstruct sidewall defects in amputated, saddle, cleft-lip, and flat noses,[22] and an anteroinferior ipsilateral septal flap for alar lining.[23] Nasal mucosa provided thin, nonobstructive internal lining. The pliability of these lining flaps minimized distortion of the overlying nasal skin. A source of lining tissue independent of the forehead facilitated the design of smaller forehead flaps because they were used solely for external covering.

Nasal Framework

It became apparent that addressing deficiencies in the nasal framework was essential to achieving optimal aesthetic and functional outcomes. The choice of tissue to replace the nasal framework has varied over the past 2 centuries. In 1863, Ollier used a forehead flap with underlying frontal bone.[28,29] Konig, in 1886, first reported using an iliac bone graft for nasal repair.[30] In 1966, Millard described a refinement of Konig's technique, using a bone graft cantilevered from the nasal process of the frontal bone.[24] The use of costal cartilage has been described by several authors. In 1889, von Mangoldt used costal cartilage for the reconstruction of saddle noses.[31] In 1902, Nelaton placed costal cartilage beneath a forehead flap and subsequently transferred it to the nose as a composite flap.[32] Although costal cartilage, when used as a free graft in the nose, remains intact 4–15 years after reconstructive rhinoplasty,[33,34] warping of the graft may occur.[35] In 1935, Gillies described using composite flaps containing septal cartilage and mucoperichondrium for the repair of defects of the nasal cartilaginous framework.[36,37] Gillies later used composite chondrocutaneous grafts to provide lining and support for alar defects.[38] Gillies' and Millard's experience with mucosal flaps and septal cartilage grafts was the basis for contemporary approaches to nasal reconstruction.

Skin Coverage

Although forehead flaps became the primary source of skin coverage for sizable nasal defects, methods of using local cutaneous flaps from the nose and cheek were developed to provide coverage for smaller defects. Nasal cutaneous flaps provided good color, thickness, and texture match with the skin at the recipient site, and their donor sites could be closed primarily. The rhombic flap was first described by Limberg in 1963,[39] and various modifications have been reported subsequently.[40–42] Although rhombic flaps are rarely used in nasal reconstruction, they may be helpful in closing small sidewall and cephalically located dorsal defects. The original design of the bilobe flap is attributed to Esser, who described it in 1918. The bilobe flap was used for reconstruction of smaller nasal defects, with the original angle of tissue transfer being 90° between each lobe of the flap. These wide angles produced significant standing cutaneous and trapdoor deformities of both lobes.[43] Modifications by McGregor[44] and Zitelli[45] were published in 1981 and 1989, respectively. Zitelli emphasized narrow angles of transfer: 45° between each lobe, with total pivotal movement of no more than 90–100°.[45] Bilobe flaps continue to be used for repair of small (2 cm or less), centrally located cutaneous defects of the caudal nose (see Chap. 10).

Another nasal cutaneous flap that is used for repair of the nose is the dorsal nasal flap (see Chap. 10). This flap was originally described by Rieger for nasal tip and midnasal wounds. The entire dorsal nasal skin, including a triangular glabellar extension, is elevated and pivoted caudally. The superior aspect of the donor site is closed in a V-to-Y fashion.[46] Refinements of Reiger's design include heminasal flaps that are created by extending an incision directly down the midline of the nose, preserving a lateral base along the nasal-facial sulcus.[47] Problems with alar retraction prompted Cronin to modify the flap by designing a narrower pedicle with a back cut through the medial canthus. He used the flap for defects less than 2.5 cm in diameter.[48] Marchac defined an axial pedicle for the flap using a branch of the angular artery. This allowed even further narrowing of the pedicle and helped to prevent nostril elevation. Marchac emphasized wide undermining of the remaining nasal skin, adjustment of flap thickness along its borders, and modification of the nasal framework to facilitate wound closure.[49,50] De Fontaine emphasized the use of the flap while still adhering to the principles of nasal aesthetic units.[51] Rohrich used the dorsal nasal flap without a glabellar incision. The flap was based on a broad lateral pedicle, as originally described by Rieger. Rohrich recommended use of the flap for defects smaller than 2 cm wide, located above the tip-defining points, and separated by at least 1 cm from the nostril margins.[52]

Cheek flaps used for nasal reconstruction date to the original description in *Sushrata Samhrita*. Melolabial flaps may be based superiorly for the repair of nasal alar or sidewall defects. They may also be based inferiorly for the repair of upper lip or columellar defects.[53] Menick introduced the interpolated melolabial flap for the repair of nasal ala defects. Interpolated flaps must be performed in two stages, but they

preserve the alar facial sulcus. When comparing forehead flaps to interpolated melolabial flaps in the reconstruction of alar defects, Arden and colleagues found that melolabial flaps provide an aesthetically superior result.[54] This is probably related to the fact that melolabial flaps have a greater tendency to contract and bulge during wound healing. This ultimately results in a contour that more closely resembles the natural appearance of the ala. Dorsal nasal, bilobe, and interpolated melolabial flaps continue to play important roles in the repair of nasal cutaneous defects.

Recent Developments

During the 1980s and 1990s, Burget and Menick made significant contributions to the art of nasal reconstruction. They stressed the importance of replacing missing nasal tissue with like tissue. Deficiencies in nasal lining were replaced with intranasal mucoperichondrial flaps, and losses of the cartilaginous framework were repaired with septal or auricular cartilage grafts. Cutaneous defects were restored with flaps from the nose, cheek, or forehead. Using these principles, Burget and Menick were able to reconstruct partial and full-thickness nasal defects, achieving optimal nasal function while closely approximating normal nasal contour and appearance.

Burget and Menick confirmed the safety of extending incisions for the forehead flap below the level of the orbital rim to give the flap added length so that it can reach the nasal tip without entering the hairline.[55–57] They also stressed that the end arterioles of the supratrochlear artery travel just under the dermis, superficial to the muscle, allowing the frontalis muscle to be safely removed from the distal end of the flap.[58] Based on Labat's and Millard's designs of unilateral pedicled flaps, Menick advocated designing the forehead flap so that its central axis is in the paramedian position. This design places the center of the flap directly over the vertical axis of the supratrochlear artery, giving the flap an axial vascular pattern. As a result, the paramedian forehead flap has a more abundant blood supply than its midline counterpart and can be based on a narrower pedicle. The narrow pedicle enables the flap to pivot more easily and to have a greater effective length.[9] Menick's description of the paramedian forehead flap was supported by anatomic studies that better defined the vascular anatomy of the forehead. The supratrochlear artery was consistently found to exit the superior medial orbit 1.7–2.2 cm lateral to the midline (see Chap. 14). The artery exits the orbit, pierces the orbital septum, and passes under the orbicularis oculi muscle and over the corrugator supercilii muscle. The artery then passes through the frontalis muscle and ascends toward the scalp in a subcutaneous tissue plane. The paramedian flap can be designed with a pedicle as narrow as 1.2 cm.[59–61]

Burget and Menick studied the blood supply of the nasal septum and determined that the septal branch of the superior labial artery was sufficient to support septal mucoperichondrial flaps for lining large, full-thickness nasal defects. They also mobilized the entire septum as a composite flap consisting of a sandwich of cartilage between two layers of mucoperichondrium so as to provide internal lining and structural support for the repair of total nasal defects. They also described the use of bipedicled flaps of residual vestibular skin and soft tissue to line the ala and nostril margin and the use of ipsilateral septal mucoperichondrial flaps to line the caudal one third of the nose.[58] The use of nasal mucoperichondrial flaps to replace nasal lining has become the standard for nasal reconstruction (see Chaps. 4 and 11). These flaps are thin, nonobstructive, and sufficiently vascular to nourish cartilage grafts. Their pliability avoids distortion of overlying nasal cartilage and skin.[57]

Burget and Menick also introduced the principle of nasal aesthetic units, which divides the nose into topographic units defined by contour lines and zones of transition between nasal skin of varying textures and thicknesses. They advocate placing scars along the junctions of these units so as to hide them in shadow lines. Flaps are designed to replace topographic units, not defects. Exact templates are created on the basis of the normal contralateral side. In general, when more than half of a unit is missing, the entire unit is resurfaced. Given the advances in aesthetic and functional results obtained by Burget and Menick, the forehead flap has gained popularity. It remains the procedure of choice for total and subtotal nasal reconstructions.[55,57,58,62]

Conclusion

The art of nasal reconstruction is well established in history, dating back to 1500 BC in India. Advances have been made during the past 2 millennia in India, Europe, and America; however, many of the refinements leading to contemporary techniques are attributed to Burget and Menick. Their work has expanded the use of cartilage grafts, mucoperichondrial lining flaps, and forehead flaps to repair smaller nasal defects in which reconstruction by other methods would provide less than optimal aesthetic or functional results. Local flaps remain an important part of the armamentarium of nasal reconstruction, having specific indications depending on the size and location of the nasal defect.

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Anatomic Considerations

2

Brian S. Jewett and Shan R. Baker

A thorough understanding of nasal anatomy is essential to successful nasal reconstruction. Addressing deficiencies of the external soft-tissue envelope, nasal framework, and internal mucosal lining is an important part of achieving an optimal aesthetic and functional outcome.

The nose is a highly contoured pyramidal structure situated centrally on the face. It is composed of skin, mucosa, bone, cartilage, and intervening supportive tissue, including fat, muscle, and connective tissue. The aesthetically pleasing nose provides a smooth and natural transition from the eyes to the lips. A distorted or deformed nose attracts attention away from the eyes and the lips, thus disrupting the aesthetic harmony of the face. Functionally, the nose is the gateway to the respiratory system. The nose warms, humidifies, and filters the air while allowing inhaled particles to come into contact with olfactory epithelium. Disruptions of normal nasal anatomy can impair nasal function and lead to complaints of nasal obstruction, nasal drainage, and compromised olfaction.

Topographic Analysis

Assessing the external nose requires an appreciation of the relationship between the nose and the rest of the face. In the frontal view, the face is divided into horizontal thirds. The upper third begins at the trichion and ends at the glabella. The middle third extends from the glabella to the subnasion. The lower third extends from the subnasion to the menton. Nasal height is measured from the radix to the subnasion and should represent 47% of the height of the face from the menton to the radix. In the vertical plane, the face is divided into fifths. Each division equals the horizontal width of a single palpebral aperture. The nasal base, the distance between the alar creases, is ideally equal to the intercanthal distance and represents one-fifth of the facial width. The nose occupies the central third of the face in the horizontal axis and the central fifth in the vertical axis and thus should lie precisely in the midline of the face. On the frontal view, a gentle, curved, unbroken line emanates from the eyebrow and courses along the lateral border of the dorsum to end at the tip-defining point. Table 2.1 defines common topographic landmarks often referred to during nasal analysis and evaluation.

A number of geometric measures are used in nasal analysis. The nasofrontal angle is the obtuse angle between a line tangent to the glabella and a line tangent to the tip-defining point, or pronasalae, with both lines originating at the nasion. This angle should measure between 115° and 130°. The nasofacial angle is the acute angle formed between a line drawn from the nasion to the pronasalae and another line drawn from the nasion to the pogonion. The angle usually measures between 30° and 40°. TAhe nasomental angle is the angle between a line extending from the nasion to the pronasalae and a line extending from the pronasalae to the menton. The nasomental angle usually measures between 120° and 132°. The nasolabial angle is the angle between the columella and upper lip; ideally it measures between 105° and 115° in females and 90° and 105° in males.

The aesthetic proportions of the ideal nasal shape and size have been established. On the lateral view, the distance from the vermilion border of the upper lip to the subnasale is equal to the distance from the subnasale to the pronasalae.[1] The distance from the alar facial sulcus to the midpoint of the nares ideally equals that from the midpoint to the caudal border of the nasal tip. On the lateral view, a right-angle triangle with the ratios of its sides being 3:4:5, and the vertices being at the nasion, alar-facial sulcus, and tip has been described to illustrate the ideal nasal proportions and size.[2] Figure 2.1 illustrates the standard directional nomenclature.

Aesthetic Units

The nose may be divided into aesthetic units by contour lines that mark zones of transition between nasal skin of differing textures and thicknesses.[3] The aesthetic units include the nasal dorsum, sidewalls, tip lobule, nasal facets, alae, and columella (Fig. 2.2). These units are highlighted when incident light is cast on the nasal surface, creating shadows along the borders of each unit and topographic landmark.[3] The

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Table 2.1 Nasal topography

Topographic landmark	Description
Trichion	Superior margin of forehead at frontal hairline
Glabella	Most prominent point in midsagittal plane of forehead
Radix	Continuous curve that descends from the superior brow to lateral nasal wall
Nasion	Depression at root of the nose, corresponds to nasofrontal suture
Sellion	Deepest point of nasofrontal angle, intersection of forehead slope and the proximal bridge
Rhinion	Junction of bony and cartilaginous nasal dorsum
Tip-defining point (pronasalae)	Anterior-most projection of nasal tip, junction of intermediate and lateral crura
Infratip lobule	Located caudal to tip-defining point and cephalic to columellar breakpoint
Columellar breakpoint	Anterior-most point of soft tissue of nasal columella, junction of intermediate and medial crura
Alar groove (supra-alar crease)	Crease located at cephalic border of ala
Alar margin	Margin along nostril rim, located at caudal aspect of ala
Alar facial sulcus	Junctional zone between cheek, upper lip, and alar base, represents lateral continuation of alar groove
Nasal facial sulcus	Junctional zone between sidewall and cheek
Subnasale	Junction of columella and upper lip
Philtrum	Midline depression in upper lip
Mentolabial sulcus	Point of depression between lower lip and chin
Pogonion	Most prominent anterior projection of chin
Menton	Lower border of soft-tissue contour of chin
Gnathion	Point located at junction of line tangent to pogonion and line tangent to menton
Cervical point	Junction of line tangent to anterior margin of neck and line tangent to menton

framework underlying the nasal skin is primarily responsible for these variations in light reflections. Therefore, precise restoration of the framework is important in the reconstruction of the nose so as to avoid contour irregularities and asymmetries. In addition, repair of nasal skin defects with a thin covering flap will help to maintain the definition of aesthetic units and anatomic landmarks.

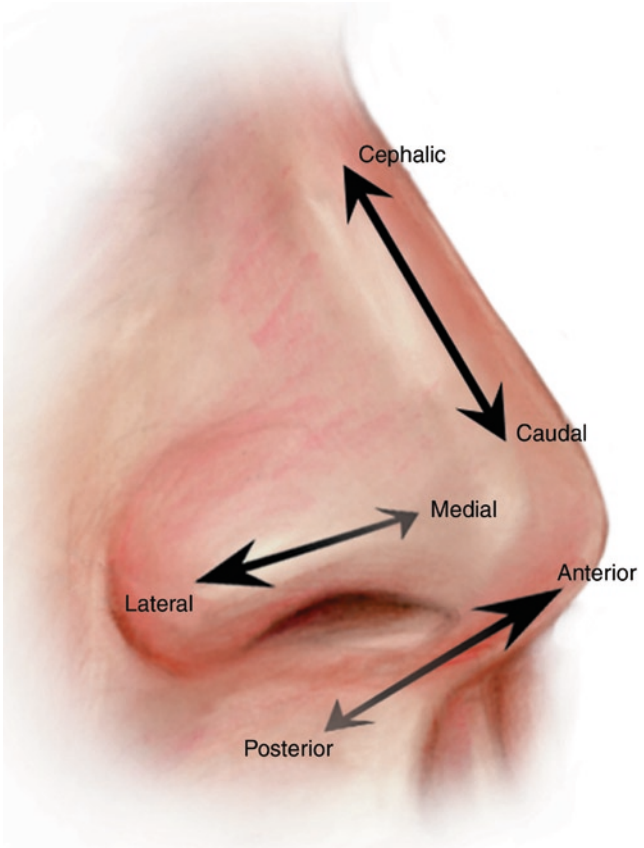

Fig. 2.1 Directional nomenclature of the nose

External Nasal Anatomy

The external nose consists of overlying skin, soft tissue, blood vessels, and nerves. Understanding the variations in skin thickness among the various regions of the nose is an essential aspect of reconstructive nasal surgery. Familiarity with the blood supply is a prerequisite to using local flaps for soft-tissue restoration of nasal defects.

Skin

Skin thickness varies widely among individuals and among the aesthetic units in any given individual (see Fig. 2.2). Lessard and Daniel analyzed 60 cadaver dissections and 25 patients undergoing septorhinoplasty and found the average skin thickness to be greatest at the radix (1.25 mm) and least at the rhinion (0.6 mm).[4] Skin is thinner and more mobile over the dorsum; whereas, it is thicker and more adherent to the underlying nasal framework at the nasal tip and alae (see

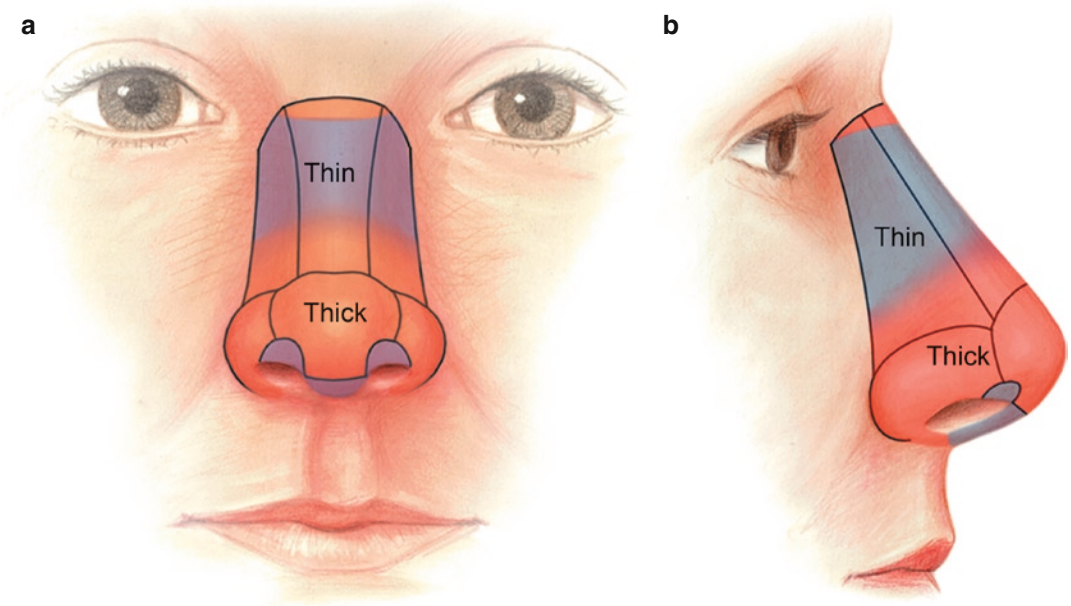

Fig. 2.2 (**a**, **b**), Aesthetic units of nose. *Blue* represents thin-skinned regions; *red* represents thicker-skinned regions

Fig. 2.2). At the cephalic portion of the nasal sidewalls, the skin is thin; however, caudally it becomes thicker in the vicinity of the alar groove. Despite being thicker at the nasal tip, the skin rapidly transitions to being very thin where it covers the nostril margins and columella. The close approximation of the dermis of the skin lining and covering the nasal facets and nostril margins makes these areas especially vulnerable to notching and contour irregularities after reconstruction.

Sebaceous glands are more numerous in the caudal half of the nasal skin. This is especially true in the non-Caucasian nose, which commonly displays a greater amount of subcutaneous fibrous fatty tissue. This dense layer of tissue, often measuring as much as 6 mm thick, obscures the contour of the underlying alar cartilages in the non-Caucasian nose.[5]

Subcutaneous Layer

Four layers compose the soft tissue between the skin and the bony cartilaginous skeleton of the nose: (1) the superficial fatty panniculus, (2) the fibromuscular layer, (3) the deep fatty layer, and (4) the periosteum/perichondrium.[6] The superficial fatty panniculus is located immediately below the skin and consists of adipose tissue with interlacing vertical fibrous septi running from the deep dermis to the underlying fibromuscular layer. This layer is thicker in the glabellar and supratip areas. The fibromuscular layer contains the nasal musculature and the nasal subcutaneous muscular aponeurotic system (SMAS), which is a continuation of the facial SMAS. Histologically, the nasal SMAS is a distinct sheet of collagenous bundles that envelops the nasal musculature. The deep fatty layer located between the SMAS and the thin covering of the nasal skeleton contains the major superficial blood vessels and nerves. This layer of loose areolar fat has no fibrous septae; as a result, immediately below it is the preferred plane for undermining nasal skin. The nasal bones and cartilages are covered with periosteum and perichondrium, which provide nutrient blood flow to these tissues, respectively. The periosteum of the nasal bones extends over the upper lateral cartilages and fuses with the periosteum of the piriform process laterally.[7] Perichondrium covers the nasal cartilages, and dense interwoven fibrous interconnections can be found between the tip cartilages.

Muscles

The nasal musculature has been described and classified by Griesman and Letourneau (Fig. 2.3).[8,9] The greatest concentration of muscle is located at the junction of the upper lateral and alar cartilages. This allows for muscular dilation and stenting of the nasal valve area. All nasal musculature is innervated by the zygomaticotemporal division of the facial nerve.[9]

The elevator muscles include the procerus, the levator labii superioris alaeque nasi, and the anomalous nasi. These muscles rotate the nasal tip in a cephalic direction and dilate the nostrils. The procerus muscle has a dual origin. The medial fibers originate from the aponeurosis of the transverse nasalis and the periosteum of the nasal bones. The lateral fibers originate from perichondrium of the upper lateral cartilages and

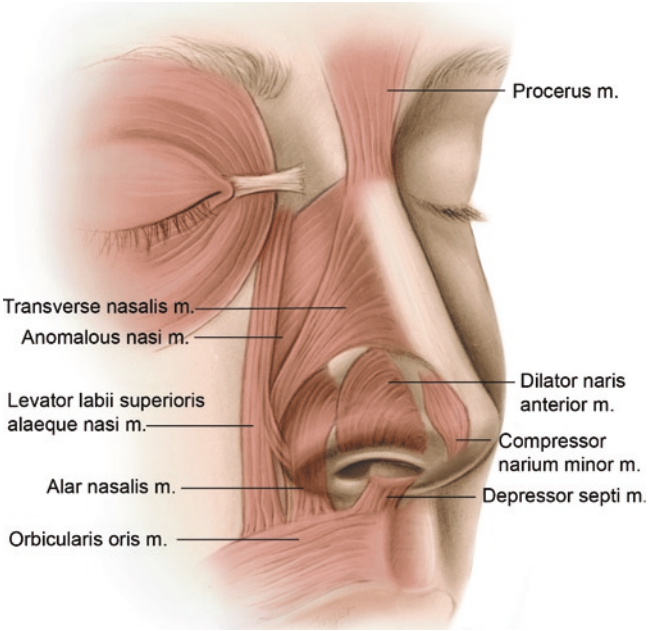

Fig. 2.3 Nasal muscles

the musculature of the upper lip. The procerus inserts into the glabellar skin. The levator labii superioris alaeque nasi originates from the medial part of the orbicularis oculi and frontal process of the maxilla and inserts into the melolabial fold, ala nasi, and skin and muscle of the upper lip. The anomalous nasi originates from the frontal process of the maxilla and inserts into the nasal bone, upper lateral cartilage, procerus, and transverse part of the nasalis.[9]

The depressor muscles of the nose include the alar nasalis and the depressor septi. These muscles lengthen the nose and dilate the nostrils. The alar nasalis originates from the maxilla above the lateral incisor tooth and inserts into the skin along the posterior circumference of the lateral crura. The depressor septi nasi originates from the maxillary periosteum above the central and lateral incisors and inserts into the membranous septum and the footplates of the medial crura. A minor dilator muscle is the dilator naris anterior, a fanlike muscle originating from the upper lateral cartilage and alar portion of the nasalis before inserting into the caudal margin of the lateral crura and the lateral alar skin.[9]

The compressor muscles rotate the nasal tip in a caudal direction and narrow the nostrils. These muscles include the transverse portion of the nasalis and the compressor narium minor. The transverse portion of the nasalis muscle originates from the maxilla above and lateral to the incisor fossa. Fibers from the transverse portion insert into the skin and procerus, and some fibers join the alar portion of the nasalis muscle. The compressor narium minor arises from the anterior part of the lower lateral cartilage and inserts into the skin near the margin of the nostrils.[9]

External Blood Supply

Both the internal and the external carotid arteries contribute to the superficial arterial supply of the nose and adjacent area (Fig. 2.4). The angular artery arises from the facial artery and provides a rich blood supply for the melolabial and subcutaneous hinge flaps used for alar reconstruction. A branch of the angular artery, the lateral nasal artery, supplies the lateral surface of the caudal nose. The lateral nasal artery passes deep to the nose in the sulcus between the ala and cheek and is covered by the levator labii superioris alaeque nasi. The artery branches multiple times to enter the subdermal plexus of the skin covering the nostril and cheek.

The dorsal nasal artery, a branch of the ophthalmic artery, pierces the orbital septum above the medial palpebral ligament and travels along the side of the nose to anastomose with the lateral nasal artery. The dorsal nasal artery provides a rich axial blood supply to the dorsal nasal skin and serves as the main arterial contributor to the dorsal nasal flap (see Chap. 10).

The nostril sill and columellar base are supplied by branches of the superior labial artery. A branch of the superior labial artery, the columellar artery, ascends superficial to the medial crura and is transected by a transcolumellar incision during an external rhinoplasty approach.

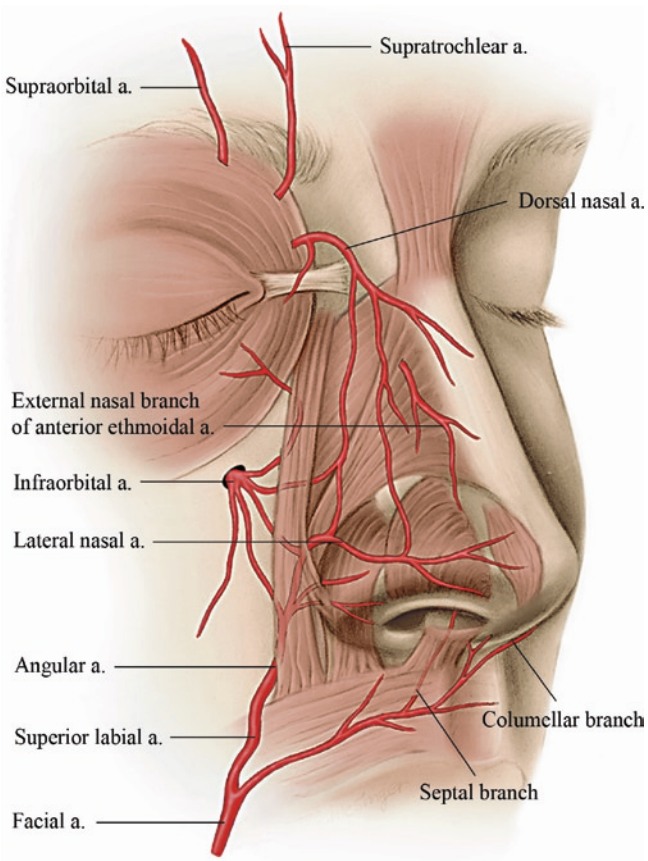

Fig. 2.4 Arterial supply of external nose

The nasal tip is supplied by the external nasal branch of the anterior ethmoidal artery as well as by the columellar artery. The anterior ethmoidal artery, a branch of the ophthalmic artery, pierces bone on the medial wall of the orbit at the point where the lamina papyracea of the ethmoid bone articulates with the orbital portion of the frontal bone (the frontoethmoid suture). The vessel enters the ethmoid sinuses to supply the mucosa and sends branches to the superior aspect of the nasal cavity. The external nasal branch of the anterior ethmoidal artery emerges between the nasal bone and the upper lateral cartilage to supply the skin covering the nasal tip. The blood supply of the nasal tip also receives contributions from the lateral nasal artery, a branch of the angular artery.

The venous drainage of the external nose consists of veins with names that correspond to the associated arteries. These veins drain via the facial vein, the pterygoid plexus, and ophthalmic veins.

External Sensory Nerve Supply

The sensory nerve supply of the nasal skin is by the ophthalmic and maxillary divisions of the fifth cranial nerve (Fig. 2.5). Branches of the supratrochlear and infratrochlear nerves supply the skin covering the radix, the rhinion, and the cephalic portion of the nasal sidewalls. The external nasal branch of the anterior ethmoidal nerve emerges between the nasal bone and the upper lateral cartilage to supply the skin over the caudal half of the nose. This nerve is usually transected by soft-tissue elevation during rhinoplasty. The infraorbital nerve provides sensory branches to the skin of the lateral aspect of the nose.

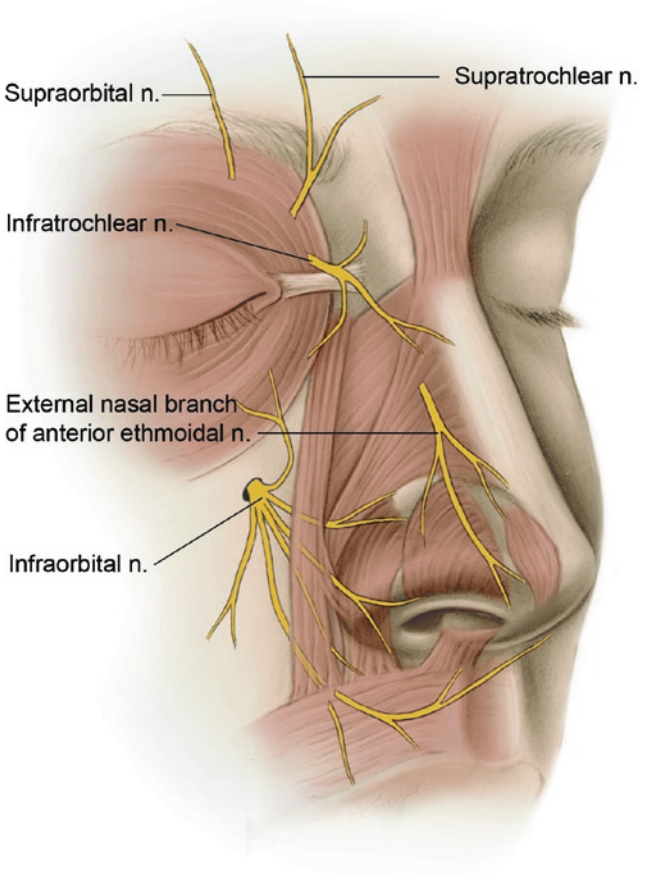

Fig. 2.5 Sensory nerve supply of external nose

Nasal Skeletal Anatomy

A thorough understanding of the nasal skeleton is essential for proper reconstruction of the nose. When constructing framework grafts, errors in duplicating normal contour may compromise the repair, leading to contour irregularities and functional limitations. The nasal framework consists of both bony and cartilaginous components (Fig. 2.6).

Nasal Tip

The caudal third of the nose consists of the lobule (tip), columella, vestibules, and alae. It is structurally supported by paired alar (lower lateral) cartilages, the caudal septum, accessory cartilages, and fibrous fatty connective tissue. The variable configuration of the nasal tip depends on the size, shape, orientation, and strength of the alar and septal cartilages and on the quality and thickness of overlying soft tissue and skin. The alar cartilages are attached to the upper lateral cartilages and the septum, and they provide the majority of the support for the tip. The vestibule is bounded medially by the septum and columella and laterally by the alar base. It contains a protruding fold of skin with vibrissae and terminates at the caudal edge of the lateral crus.

The alar cartilage is subdivided into medial, intermediate, and lateral crura (Figs. 2.7 and 2.8). The medial crus consists of the footplate and columellar segments. The footplate is more posterior and accounts for the flared portion of the columellar base. The columellar segment begins at the upper limit of the footplate and joins the intermediate crus at the columellar breakpoint. The breakpoint represents the junction of the tip and the columella. The appearance and projection of the columella are influenced by the configuration of the medial crura as well as that of the caudal septum. Intervening soft tissue between the columellar segments of the medial crura may fill this space; however, in patients with thin skin, the columella may have a bifid appearance. Columellar asymmetries may be secondary to deflections of

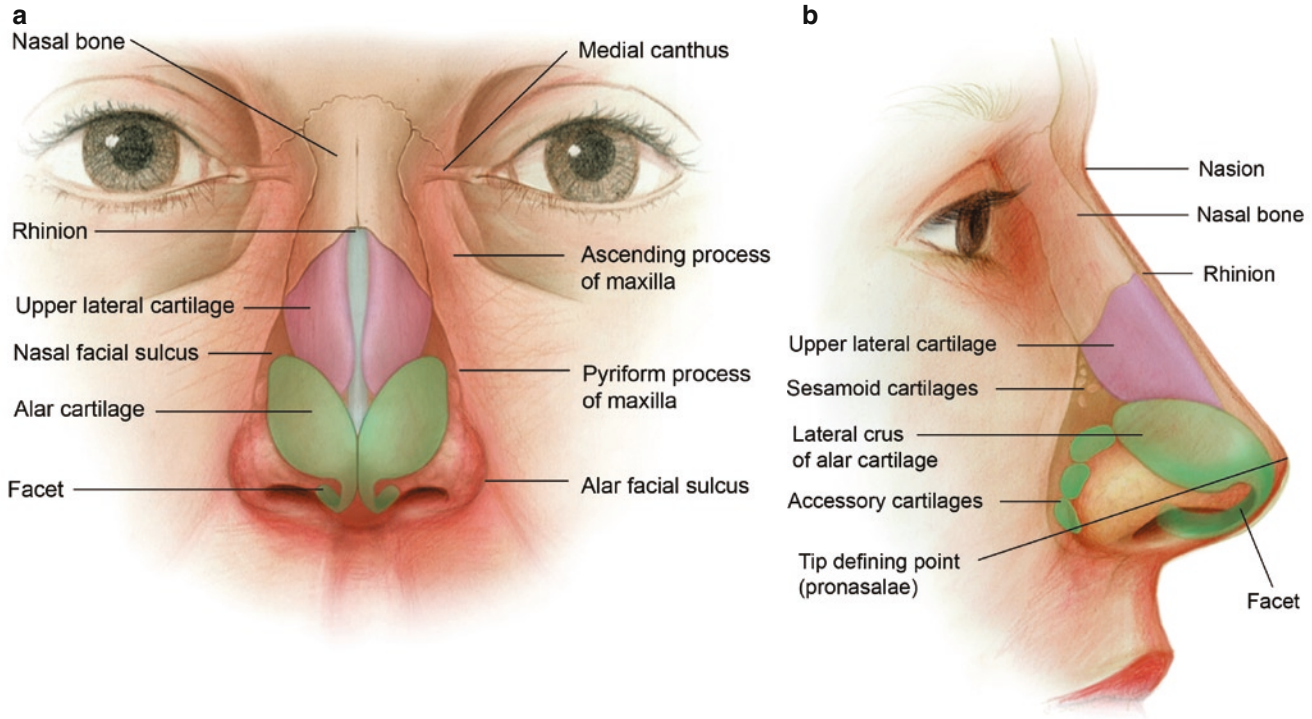

Fig. 2.6 (**a**, **b**) Nasal framework and soft-tissue relationships

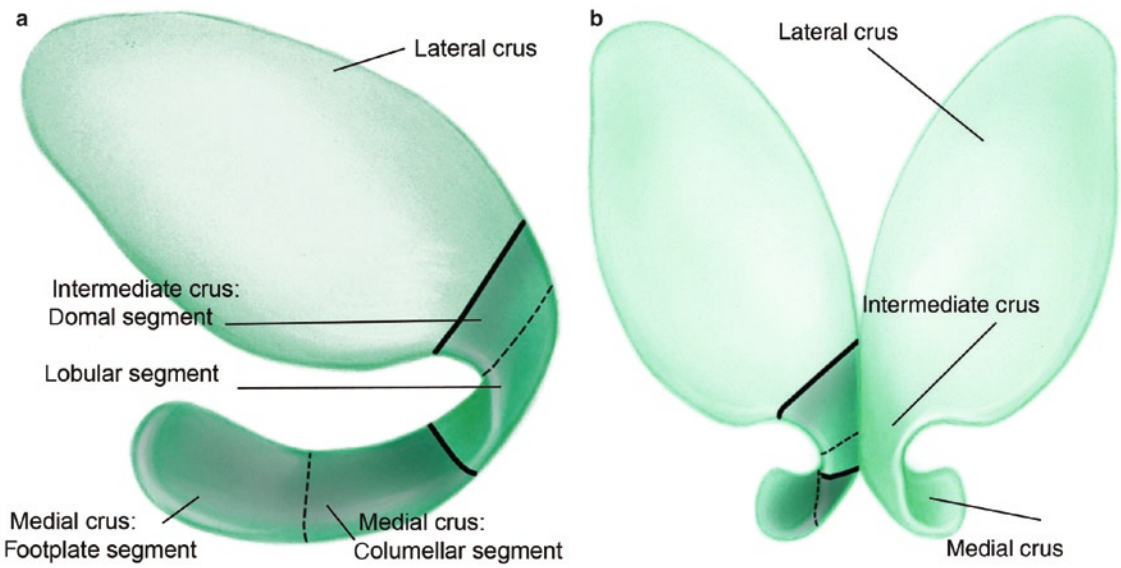

Fig. 2.7 (**a**) Lateral view of alar cartilage. (**b**) Frontal view of paired alar cartilages

the caudal septum or intrinsic asymmetries of the alar cartilages. In the aesthetically pleasing nose, the columella is positioned 2–4 mm caudal to the nostril margins, and the shape of the nasal base resembles an equilateral triangle. Attractive nostrils are teardrop-shaped, in the opinion of many.

The intermediate crura consist of a lobular and a domal segment. In the majority of noses, the cephalic borders of the lobular segment are in close approximation, and the caudal margins diverge.[10] The intermediate crura are bound together by the interdomal ligament, and lack of intervening soft tissue may give the tip a bifid appearance. On a lateral view, the

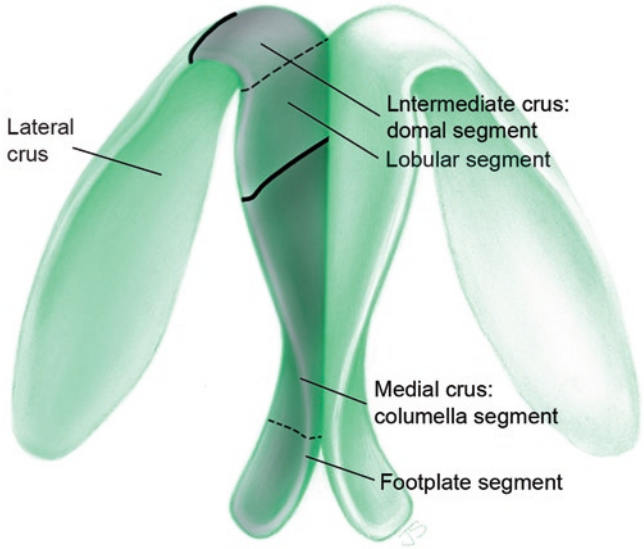

Fig. 2.8 Base view of paired alar cartilages

internal structure responsible for the prominence of the tip-defining point, or pronasalae, is the cephalic border of the domal segment of the intermediate crus. Thus, the shape, length, and angulation of the intermediate crura determine the configuration of the infratip lobule and the position of the tip-defining point. The supratip breakpoint is the junction between the intermediate crus and the lateral crus.

The lateral crus is the largest component of the alar cartilage; it provides support to the anterior half of the nostril rim. Resection or weakening of the lateral crus causes a predisposition to nostril retraction and notching, an important consideration during nasal reconstruction. Laterally, small sesamoid cartilages are interconnected by a dense, fibrous connective tissue that is contiguous with the superficial and deep perichondrium of the upper lateral cartilage and lateral crus. Inferolaterally, the ala contains fat and fibrous connective tissue but no cartilage. The shape and resiliency of the nostril depend on the dense, fibrous, fatty connective tissue located within the confines of the ala, and the integrity of this area should be restored with cartilage grafting when necessary.

Cartilaginous Dorsum

The cartilaginous dorsum consists of paired upper lateral cartilages and the cartilaginous septum (see Fig. 2.6). The upper lateral cartilages are overlapped superiorly by the bony framework for a variable distance. The free caudal border of the nasal bones has fibrous connections to the cephalic margin of the upper lateral cartilages. The cephalic two-thirds of the cartilaginous dorsum is a single cartilaginous unit. However, caudally, there is gradual separation of the upper lateral cartilages from the septum. The lateral borders of the upper lateral cartilages are rectangular in shape and are connected to the piriform aperture by an aponeurosis.[10] The lateral border of the upper lateral cartilage creates a space known as the external lateral triangle. This space is defined by the lateral border of the upper lateral cartilage, the extreme lateral portion of the lateral crus, and the border of the piriform fossa. The space is lined by mucosa and covered by the transverse portion of the nasalis muscle. It may contain accessory cartilages and fibrous fatty tissue that contribute to the lateral aspect of the internal nasal valve. Nasal obstruction may occur as a result of medialization of this space by scar tissue or cartilage grafts used in nasal reconstruction.

Bony Dorsum

The bony dorsum consists of paired nasal bones and paired frontal processes of the maxillae (see Fig. 2.6). The bony vault is pyramidal in shape, and the narrowest part is at the level of the intercanthal line. The bony dorsum is divided approximately in half by the intercanthal line, and the nasal bones are much thicker above this level.[11] The sellion is the deepest portion of the curve of soft tissue between the glabella and nasal dorsum, and it marks the level of the nasofrontal suture line. The nasion is approximately at the level of the supratarsal fold of the upper eyelid. Laterally, the nasal bones articulate with the frontal processes of the maxillae.

Internal Nasal Anatomy

Reconstruction of full-thickness defects of the nose requires restoration of the external skin, the nasal framework, and the internal nasal lining. Failure to address deficiencies in nasal lining may lead to postoperative scarring contracture, and functional compromise. A brief description of the internal nasal anatomy pertinent to nasal reconstruction follows.

Nasal Cavities

The nose is the gateway to the respiratory system. Partitioned by the septum, the nose provides two independent passages between the nostrils and the nasopharynx. Each passage is lined circumferentially with ciliated psuedostratified columnar epithelium. The nasal cavities begin at the limen nasi, which is the junction between the vestibule, lined with squamous epithelium, and the nasal cavities, lined with respiratory epithelium.

Along the lateral aspect of the nasal passages, the turbinates create a complex of mucosally lined peaks and