The Tripod Theory of Nasal Tip Support Revisited

The Cantilevered Spring Model

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Objective: To extrapolate on the tripod concept to create a more universal and multiethnic model that includes common anatomical configurations and strategies to avoid certain unwanted surgical outcomes.

Methods: Analysis of current surgical methods, scientific studies, and predominant theories to produce a new model of nasal tip support based on the biomechanical properties of the nasal cartilages.

Results: The nasal tip acts as a cantilevered spring that associates with other rigid and semirigid regions of the nose. Application of these concepts resulted in preservation of projection and tip rotation in appropriately selected patients.

Conclusion: The cantilevered spring tripod provides a more universal model for explaining nasal tip dynamics in a contemporary multiethnic population of patients seeking functional or cosmetic rhinoplasty correction.

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MAINTAINING THE STABILITY of the nasal tip continues to be one of the more challenging aspects of functional and aesthetic rhinoplasty. Since the 1960s, the tripod concept has been the predominant theory used to explain nasal tip dynamics and has helped to guide common surgical practice and resident education. Recently, an increased appreciation for racial/ethnic variability and alterations in nasal ideals has occurred, making the strict application of a pure tripod model less universal. Based on prior biomechanical testing of the nasal tip and extensive rhinoplasty experience, we have expanded on Anderson's original premise to produce a model for nasal tip dynamics that, while still incorporating the tripod concept, looks at the cartilages in relation to their intrinsic and surrounding external forces. The nasal tip, like a cantilever, is a projecting structure that is supported along its length by a rigid abutment. Because the nasal tip exhibits elastic behavior, the paired tip cartilages can be seen to act as a cantilevered spring tripod that has a single point of rigid fixation, often along the caudal septum. In this model, the lower lateral cartilage complex produces an upward force that is in the form of stored elastic potential energy. The energy balance between intrinsic and extrinsic forces results in the ultimate position of the nasal tip. A discussion of our force analysis, clinical correlates, and perioperative Goode ratios of all representative patients is presented herein.

Since the 1960s, the tripod concept by Anderson[1] has been the main theory used to explain nasal tip dynamics. There has been no significant investigation into this concept, and it has persisted, essentially untouched, for more than 40 years. This longevity is a testament to its strength and validity. Although it was originally described as a concept, over the years it has become accepted as theory. The tripod concept along with the major and minor tip support mechanisms of Janeke and Wright[2] have collectively become the main tools for teaching and describing basic methods for lower lateral cartilage alteration and tip dynamics.

In the most basic sense, the theory according to Anderson[1] defines a tripod formed by the combined medial crura and the paired lower lateral crura. This tripod essentially rests on the anterior nasal spine and is supported laterally by soft-tissue attachments to the nasal pyramid, sesamoid cartilages, and upper lateral cartilages. Centrally, the soft-tissue attachments to the septal angle and caudal septum help to maintain stability. Anderson

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described ways to modify this pyramid: rotation, derotation, and deprojection could be accomplished by shortening the lateral arms, the medial arms, and both arms, respectively.

At the time of the landmark publication by Anderson,[1] there was a preponderance of patients with leptorrhine nasal architecture undergoing rhinoplasty surgery. Neoclassic canons were used as the standards for nasal and facial analysis, and the confluence of these factors made this theory applicable, leading to its universal acceptance. Many basic tenets of tip modification were derived from the original tripod concept and persist to this day.

As facial plastic surgery became more popular and mainstream toward the end of the 20th century, racial/ethnic anatomical variability began to be appreciated. At the same time, the conventional concepts of beauty were redefined, and the goal of creating classic leptorrhine standards was selectively abandoned. The current concept of nasal aesthetics is more universal, embracing and incorporating racial/ethnic differences and applying new concepts of beauty. This has been paired with a surgical emphasis on preservation, reconfiguration, and conservatism, with an increased appreciation for providing medial tip support using grafts, permanent suture techniques, and caudal septal interposition.[3-5]

In light of these practice shifts, it seems remarkable that little has been done to further investigate the structural elements of the nasal tip, especially when considering the growing body of literature describing new surgical techniques for various races/ethnicities and nasal subtypes. When one takes a step back from conventional wisdom, it becomes clear that our thinking has radically changed, while our underlying theories have remained static.

The cantilever spring theory describes the paired lower lateral cartilages as having a single point of fixation, usually along the caudal septum, around which the elastic tripod will rotate. Authors have previously described how these cartilages produce an upward force.[1,6,7] Cantilever theory further defines this as elastic spring potential energy. This spring potential energy–based model of tip biomechanics is supported by the observation that the tip cartilages exhibit the inherent spring properties of recoil, deformation, and elasticity.

The cantilevered spring model explains why similar surgical maneuvers produce different aesthetic effects depending on a patient's underlying anatomy. This biomechanical approach explains how certain unwanted surgical outcomes can occur, including deprojection, polybeak formation, and postoperative or refractory nasal tip ptosis. Its direct practical application is to identify those patients requiring structural grafting, as well as to help the surgeon recognize those who do not. If a patient has a cantilever point that is cephalic and biomechanically unfavorable, then medial grafting is required to produce a favorable cantilever point at the columellar base to prevent deprojection or derotation. We believe that this model incorporates the tripod concept and the major nasal tip support mechanisms into a single unifying theory that can be easily, predictably, and universally applied.

METHODS

ANALYSIS OF CURRENT CONCEPTS

There are several key assumptions that must be made to universally apply the tripod concept to every patient. The first is that the tip tripod is supported by 3 equally rigid platforms. The second is that 3 legs of equal height and strength exist. The third is that no external forces are acting on this structure and that it can exist as a freestanding unit. The fourth is that patients function in the supine state only, where gravity affects the medial and lateral legs equally.

The tripod theory represents the conceptualization of only a single major tip support mechanism, namely, the strength and architecture of the lower lateral cartilages. Current surgical practices have deemphasized the other classic major tip support mechanisms, including the medial crural attachment to the caudal septum and the scroll region, both of which are often disturbed in rhinoplasty.

Contemporary techniques focus on modification of the cartilages, which seem to be gaining importance over all other classically defined major and minor support mechanisms. There is an emerging understanding that dynamic and isometric forces act on the lower lateral cartilages. Most of these external forces are in a posterocaudal direction, the vector and magnitude of which differ among patients. This can result in changes to nasal tip appearance over time, as demonstrated by long-term postoperative sequelae and in senile nasal tip ptosis.

ANALYSIS OF CURRENT SURGICAL PRACTICE

Clinical evidence for these assertions is also found in the current algorithms for nasal tip refinement. Open rhinoplasty approaches, which are designed to preserve the "major" nasal tip supports (lower lateral cartilage strength, the scroll region [if no cephalic trim is performed], and the caudal septal attachment to the medial crural feet), often use multiple structural grafts, while closed approaches, which sacrifice more of the classically accepted supporting elements, often use less grafting. The caudal septum, which is often ignored in nasal tip support discussions, is increasingly being used to provide a rigid platform for the nasal tip with tongue-in-groove techniques,[3] dynamic adjustable rotational tip grafts,[4] or caudal septal extension grafts.[5]

The following questions should be raised based on experimental and clinical evidence: (1) How significant are the other assumed nasal tip support mechanisms, and are they universally applicable in the population of patients seeking rhinoplasty? (2) Do the paired scrolls provide any significant support to the tip? (3) How universal is the distinction between major and minor mechanisms? (4) Are noses in individuals seeking reduction rhinoplasty structurally different from those in individuals requiring augmentation procedures? Are these patients similar to those not seeking functional or aesthetic rhinoplasty modifications? (5) Why is structural grafting and permanent suturing so commonly used today? (6) Why do some vertical division techniques that destroy the tripod result in increased nasal tip projection? (7) If the nasal tip is a mobile structure, then how can its tripod have 3 stable foundations? (8) Why would interposition of the lower lateral cartilages to the caudal septum be necessary to control nasal tip position if the septum is a minor support element? (9) Is the isometric contact or association of the caudal septum with the medial crural feet, rather than a structural attachment, the truly important platform for tip support? (10) Why do dome-binding techniques that incorporate the lateral crus into the new domes pro-

duce projection rather than the deprojection predicted by the tripod theory?

BIOMECHANICAL ANALYSIS

Our attempts to clinically and experimentally answer these questions led us to reconsider the underlying basis for the tripod theory and to reach the following understanding: The application of a pure tripod concept can only be considered when the surgeon determines that all 3 legs are equally strong and well supported. This is the case in only a small subset of patients with leptorrhine nasal architecture. Otherwise, if one leg's stability exceeds the other, as in most nasal architectures, then that leg's fixation point is predominant, and a cantilevered system exists. The nasal tip, like a cantilever, is a projecting structure that is supported at 1 end, while carrying a weight along its length.

As shown in a previous publication on nasal cartilage biomechanics, the nasal cartilages have varied strengths that seem to relate to their observed purpose.[6] The septum is the strongest element of the nose, which correlates with its rigid but flexible nature. The upper lateral cartilages have a medium level of stiffness, as they are semimobile elements. The lower lateral cartilages have the lowest modulus of elasticity, which may decrease significantly as one approaches the region of the scroll.[6]

Because the attachments of the tripod are soft tissue, the cartilaginous elements are elastic but weak, and the tripod is flexible; it is essentially a spring-loaded tripod that gains its stability from a rigid abutment. This septum is the most likely cantilever point because of its midline position and highest modulus of elasticity among the nasal cartilages.

Furthermore, even when a balanced tripod exists before surgery, when surgical incision, excision, or grafting is performed, an imbalance results, converting the tip into a cantilevered structure that moves rotationally around the most stable fixation point, the nasal septum. This movement around the cantilever point can be cephalad or caudal in direction depending on the overall force balance following tip modification and the maneuvers used.

Previous publications have described the nasal tip as an energy-producing structure but have not incorporated that concept into a formal model. For example, Anderson[1] compared the nasal tip to a "sprung horseshoe" and described the force of lateral crural hypertrophy as a cause for nasal tip ptosis. In addition, the M-arch model to the nasal tip, recently proposed by Adamson et al,[7] reinforces the idea that the elastic spring-like nature of the tip should be considered in analyzing the effects of surgical maneuvers on the nose.

RESULTS

BASIC CANTILEVERED SPRING THEORY

The nasal tip, like any other structure, must have balanced forces acting on it to remain stable. Therefore, the tip cartilages must be producing energy in an upward direction to oppose the downward forces acting on them. This energy is clearly not kinetic, as the tip is stable in its position. Because of the downward direction of most external forces (including gravity, the skin–soft-tissue envelope weight, nasal superficial muscular aponeurotic system movement, and depressor septi pull), the nasal tip must produce an upward force vector that in a stable situation is equal and opposite in nature. Therefore, the lower lateral cartilages must be producing energy in the form of stored elastic potential energy. This overall energy bal-

ance is the most important anatomical determinant of nasal tip position.

Evidence to this effect can be seen in senile nasal tip ptosis. Increasing skin thickness and, potentially, a decrease in the inherent cartilage strength may be occurring. Homicz et al[8] demonstrated age-dependent changes within the nasal septal cartilage. A similar change is likely occurring in the lower laterals as well, resulting in a decreased cephalic potential energy vector. The sum total of these forces causes an alteration to the balance, with a downward rotational displacement vector that causes the nasal tip to derotate or deproject. This phenomenon is well explained using cantilevered spring theory.

An equation for calculating the elastic potential energy in this system was previously published.[6] This equation was derived using a cantilevered spring model as follows:

$$PE = \frac{1}{2}\left(\frac{E(w \times h)^3}{4L^3}\right)x^2,$$

where PE indicates potential energy; E, the elastic modulus of the spring; w, width; h, height; L, length; and x, displacement of the spring. Therefore, for a stable system in which the nasal tip is static, the concept can be further simplified with the following balanced force equation:

Downward Forces = Cantilevered Spring Potential Energy + Other Tip Support Elements

These equations show how some surgical maneuvers will tend to reduce the elastic potential energy of the system, while others may enhance it. Changes to the length will have the most profound effects on overall energy, while changes to the height and width will have a lesser effect by a factor of one-quarter.

Cephalic trim reduces the width, which reduces the numerator, causing a decrease in elastic potential energy of the lateral crura only. It also causes an imbalance between the lateral and medial legs of the cantilevered tripod. When a columellar base (posterior septal angle or anterior nasal spine) cantilever point is present, rotation will result until contact is again made at the caudal septum or the caudal edge of the upper lateral cartilages, producing an equal and balanced downward isometric force.

Dome-binding maneuvers, in effect, double or quadruple the height or thickness of the cartilage, which will exponentially increase the amount of elastic potential energy stored in the medial and lateral legs, causing projection. Rotation that is achieved with this maneuver depends on the amount of lateral crural steal achieved with the dome binding. This maneuver alters the overall geometry of the cartilage and shortens the effective cantilever beam length, increasing elastic potential energy and producing projection and rotation simultaneously.

Batten grafts and alar strut grafts thicken or increase the height of the cartilage, causing an increase in elastic potential energy of the lateral legs only. This can cause volume addition with or without derotation depending on the relative strength of the medial crura and the location and stability of the cantilever point. Placement of these grafts alone will never produce projection or rotation.

Dome division techniques will decrease the overall length without affecting width or height, causing the greatest increase in energy of all described maneuvers and the most profound increase in nasal tip projection and rotation. An effect is also gained from creating an independent central unit, consisting of a single leg or "monopod" that is disassociated from the lateral crura. This is critical in noses in which the extreme lateral crural strength or length contributes to a ptotic nasal tip (eg, Middle Eastern noses).

Placing a columella strut thickens the columella (height), which causes an increase in elastic potential energy. This technique is used in patients with poor medial support, which means that a more cephalically based cantilever point is present before surgery. Moving the cantilever point from an unfavorable cephalic position to a more stable caudal region at the base of the columella creates a mechanical benefit that allows traditional rotational maneuvers to be successful.

EFFECTS OF CANTILEVER PIVOT POINT ALTERATION

If the cantilever pivot point represents the most significant foundation to the tip complex, then alterations to that region should cause analogous changes to the position of the lower lateral cartilage. The proposed force equations assume a stable and rigid cantilever point. If this region is altered, then the lower lateral cartilages will move accordingly to establish a new balanced positional state. This equilibrium is achieved through isometric associations of the lower lateral cartilage along the caudal septum and intercartilaginous region. Weakening the cantilever point causes settling, while grafting to the region produces projection.

Deprojection that occurs from dorsal reduction is a common example of cantilever point alteration. This effect is seen in patients with tension noses or infantile and underdeveloped lobules in which medial support is often deficient. The anterior septal angle is the cantilever point in these situations and the tip is suspended by it. Reduction in the dorsal quadrangular plate lowers the cantilever point. In the absence of medial grafting that creates a different cantilever point, the tip will settle until it is again supported at the anterior septal angle. This explains why these patients are classically at high risk for polybeak formation. The only way to avoid the cantilever point contribution is to reduce the septum aggressively. This allows the tip to deproject until the medial crura impact the columellar base, creating a new cantilever point at the expense of deprojection.

Medial crural trim, spine reduction, and posterior angle reduction are other examples of cantilever point modification. Only patients with strong medial support and long medial crura should be treated in this manner. These patients approximate the leptorrhine standard in which the cantilever point lies at the base of the medial crura. Posterior relocation of the cantilever point through anterior nasal spine reduction or posterior septal angle trim causes a similar reduction in nasal tip height and some derotation. Although medial crural trim also produces these effects, it is often less pronounced. This is likely a result of the increased potential energy gained from shortening the overall cantilever beam length.

SURROUNDING FORCE ALTERATION

The rotational effect from caudal septal trim is an example of a clinical scenario that is unexplained by the potential energy equation but is reflected in the balanced force equation. In this circumstance, the surgeon is modifying the surrounding external forces that are opposing the upward thrust of an inherently supported tip, specifically the association of the caudal septum and the medial crura. This allows the tip to rotate cephalically until contact is again made, creating an isometric force equilibrium. This is also true of the scroll region, where upper lateral cartilage trim or cephalic trim exclusively produces rotational effects in patients with strong medial support. If a favorable cantilever point is not present, deprojection or ptosis may result from these same maneuvers.

This association effect at the regions of the scroll and caudal septum can be further supported by the concept of the nasal break point. This break point is the profile location at which the mobile tip and the rigid upper nasal two-thirds associate. Milgrim et al[9] demonstrated that its location and distance along the nasal dorsum differed among various Latin racial/ethnic populations. The authors showed that the mobile and semirigid components of the nose have a distinct point of association in different nasal subtypes that correlated with different underlying anatomy.

Our analysis of the forces acting on the nasal tip suggests that the scroll and the caudal septum are points of isometric (equal and opposite) force transduction between the cartilaginous elements of the nose. Therefore, modifications in which the opposing cartilaginous elements are stable and strong will allow for movement toward the resected element until a new isometric equilibrium is established via direct cartilage-cartilage or soft-tissue contact.

COMMENT

Using the cantilevered spring equation, we were able to analyze the relative importance of length, width, thickness, and intrinsic cartilage strength in determining the ability of the nasal tip to withstand the external forces that act on it. Most external forces acting on the nose are posterocaudal in nature. To remain static, the nasal tip complex must produce an equal and opposite upward force vector, which manifests as potential energy.

The cantilever concept arose from the clinical experience of one of us (W.L.) in which it was noted that the lateral and medial legs of the tripod were of unequal length and strength in most patients and that a stable projected tip could be maintained even after they were separated from one another. According to the original theory, the ultimate position of the nasal tip is determined by the relative lengths of the medial and lateral elements. That theory proves correct only when all 3 legs are resting on equally stable supporting platforms.

Collective clinical experience and evolving alterations in rhinoplasty techniques by surgeons across the country led us to believe that the current theories of nasal tip biomechanics were insufficient to explain contemporary surgical practice. In our experience, the na-

sal tip represents a swinging springlike tripod with varied pivot points for different nasal subtypes.

Each nose has a specific pivot point from which the classic tripod will move or rotate. In each scenario, the location of the pivot point is determined by the anatomy of an individual patient. The important nasal tip support structures are not necessarily reflected by the classic descriptions by Janeke and Wright.[2] Common anatomical variations will have varied support elements of significance that produce different pivot points along the cantilever, which is usually the caudal septum. In every case, the strength and geometry of the lower lateral cartilages are major determinants of nasal tip support, as they directly affect the magnitude of the potential energy vector of the lower lateral cartilage.

CLINICAL QUESTIONS

Some clinical scenarios that are unexplained by the tripod model but are explained using the cantilever spring
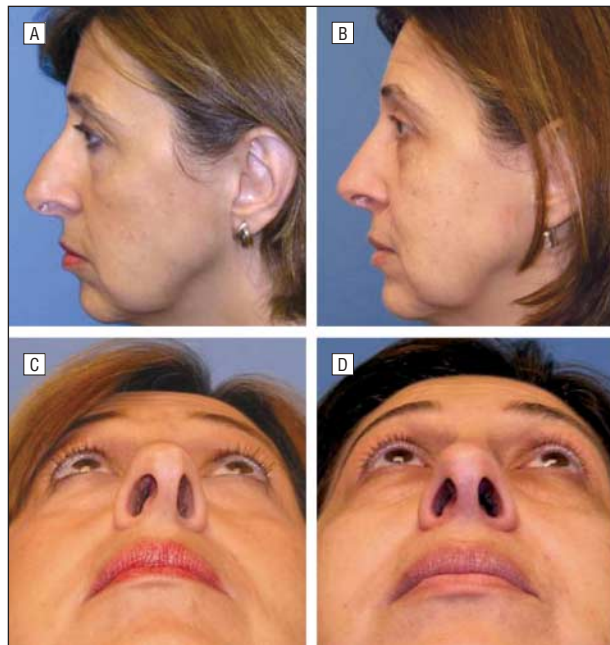

Figure 1. The classic leptorrhine nose represents a tripod with excellent medial and lateral support. A and C, Before surgery. B and D, After surgery including caudal septal excision and septoplasty, cephalic trim, and dorsal reduction.

theory include the following: (1) rotation that is achieved from caudal septal shortening or cephalic trim alone or in conjunction (visor effect[1]), (2) nasal tip ptosis that can occur after cephalic trim, (3) alar collapse from lateral crural overresection without increased rotation, (4) alar collapse from lateral crural overresection with nasal tip ptosis, (5) the nasal tip sequelae of saddle nose deformities in which only septal support is lost, (6) deprojection that sometimes occurs from dorsal nasal reduction, (7) polybeak formation, (8) deprojection that sometimes occurs from performing a full transfixion incision, (9) projection and rotation that are obtained from dome-binding techniques in the absence of additional structural grafting, and (10) an increase in tip projection that is sometimes achieved with caudal septal repositioning alone.

Other clinical scenarios in which the classic tripod theory is not readily applicable include many racial/ethnic noses with poor medial support. Specific anatomical variants cannot be treated using the principles of the tripod theory, including tension noses, nasal tip ptosis, severe lateral crural hypertrophy, infantile or underdeveloped lobules, extreme cephalic orientation to the lateral crura, bimaxillary protrusion or anterior nasal spine retrusion, and noses in which the tip lies in a dependent position in relation to the anterior septal angle. Consequently, many publications have described methods to approach tip modification in these patients. However, no overarching theory provides a basis for management of these anatomical deviations from the classic leptorrhine standard that do not approximate a stable tripod.

CLINICAL CORRELATES

The classic leptorrhine nose (**Figure 1** and **Table 1**) represents a tripod with excellent medial and lateral support. As stated before, this is the only clinical scenario that can predictably be treated using the original tripod theory. These patients have adequate nasal spine length, long and strong medial crura, and balanced medial and lateral crural components. On base view, the medial crura will span the length of the columella and will bend with minor digital retrodisplacement of the tip.

An imbalance in the medial and lateral cartilage segments results when surgical alteration of the lateral crura is performed. This creates a cantilever point at the colu-

Table 1. Goode Ratio Analysis of Patients Shown in the Figures[a]

| Figure | Preoperative, Pixels | | Postoperative, Pixels | | Length to Projection Ratio | |
	Length	Projection	Length	Projection	Preoperative	Postoperative
1	0.467	0.316	0.415	0.280	0.676	0.674
2	0.367	0.622	0.360	0.599	0.590	0.601
3	0.559	1.042	0.511	1.075	0.536	0.475
4	0.991	1.485	0.866	1.445	0.593	0.599
5	0.560	0.985	0.580	0.974	0.568	0.595
6	0.371	0.227	0.342	0.265	0.611	0.774
8	0.461	0.290	0.494	0.353	0.629	0.714

[a] Goode ratio was calculated according to usual standards as a way of demonstrating maintenance, loss, or augmentation of nasal tip projection as it relates to overall nasal length. We found no significant difference between the paired preoperative and postoperative measurements (P = .27, paired t test [Excel; Microsoft, Redmond, Washington]).
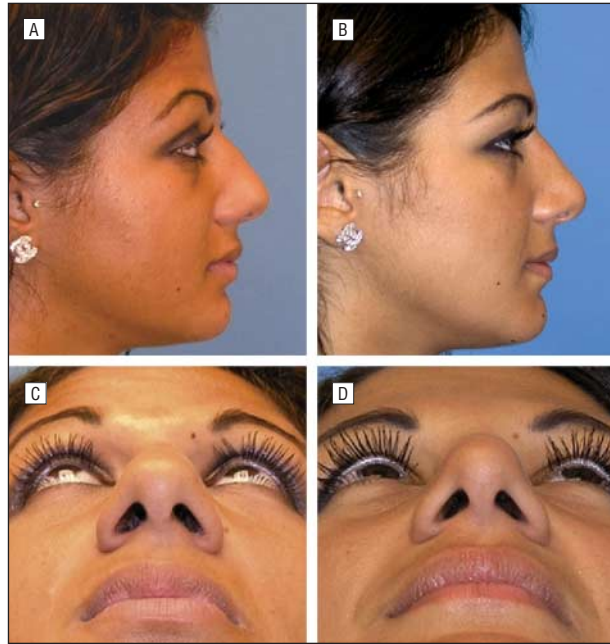
Figure 2. Columellar base cantilever. Projection is often maintained in the absence of grafting and is frequently augmented using dome-binding techniques alone. A and C, Before surgery. B and D, After surgery including septoplasty, dome binding, cephalic trim, and dorsal reduction.

Figure 3. Anterior septal angle cantilever. In this anatomical configuration, dorsal reduction without tip grafting will result in nasal deprojection because of cantilever point modification. A and C, Before surgery. B and D, After surgery including dorsal reduction only. Tip deprojection was desired by the patient.
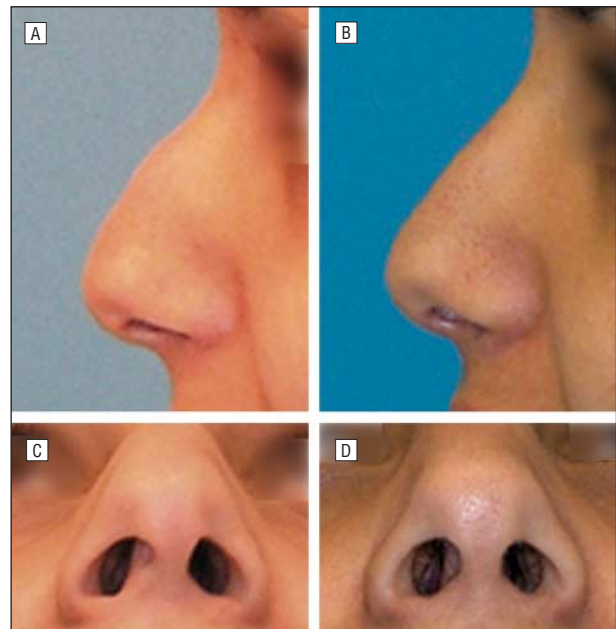

Figure 4. When a cephalic cantilever point is present (anterior septal angle), projection can be maintained by grafts that move the cantilever point to the columellar base. A and C, Before surgery. B and D, After surgery including dorsal reduction, caudal septal reduction, septoplasty, and a columellar strut.

mellar lip junction from the association of the medial crura with the posterior septal angle. Therefore, cephalic trim will rotate by decreasing the caudal isometric force at the intercartilaginous region. Caudal septal shortening will also rotate by decreasing the isometric force of the caudal septum on the nasal tip. Projection is often maintained in the absence of grafting and is frequently augmented using dome-binding techniques alone (**Figure 2**). Derotation and some loss of projection can be obtained by trimming the posterior septal angle, by anterior nasal spine reduction, or by trimming the medial crural feet, which alters the cantilever point to establish a new posteriorly placed equilibrium point.

An unexpected loss of projection may be seen in patients with caudal septal dislocation in which the basic foundation of the tip cantilever lies off of midline. If left uncorrected, these patients are at high risk of nasal deprojection following rhinoplasty unless a columellar strut of sufficient length is placed to cantilever off of the anterior nasal spine. The importance of the caudal septum and its midline position to nasal tip buttressing has been supported by the preponderance of available experimental evidence to date.[10-12]

Deprojection is also seen in patients with dependent tips, tension nose deformity, or infantile lobules. These patients have a tripod that is balanced at the point of the anterior septal angle. The anterior septal angle often is the true tip-defining point that can be seen clearly when the tip is posteriorly displaced. On base view, the medial crura often flare halfway up the columella and are deficient in length. Another clue to this deficiency is the absence of significant medial crural bowing with light retrodisplacement of the tip. It is easy to see that the nasal tip is cantilevered, almost suspended, at the anterior septal angle by the association of the septum with the domes

and the interdomal ligament, a concept supported in clinical investigations by Beaty et al.[12]

In this anatomical configuration, dorsal reduction without tip grafting will result in nasal deprojection because of cantilever point modification (**Figure 3**). In these patients, cephalic trim or caudal septal shortening will not

Figure 5. Dependent tip with anterior septal angle cantilever. Strip division, overlay, or crural steal techniques are often required in patients with lateral crural hypertrophy. A and C, Before surgery. B and D, After surgery including caudal septoplasty, lateral crural steal double dome binding, and a columellar strut.
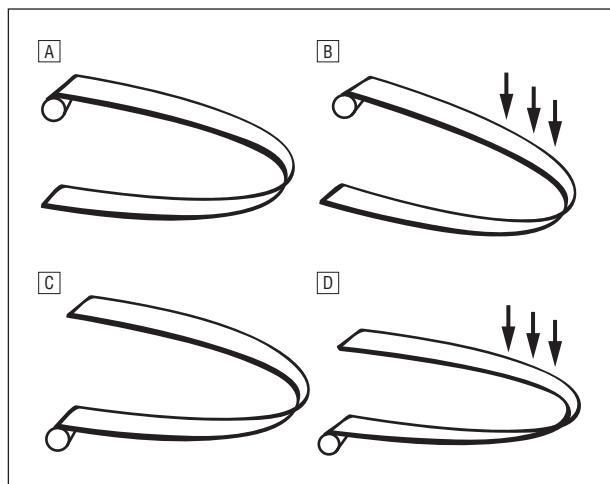

Figure 7. Schematic illustrating how a caudal force (arrows) affects an arched spring with cephalic (A and B) and caudal (C and D) cantilever points.

Figure 6. Pyriform or sesamoid complex cantilever. Strip division techniques are successful because they modify the pivot point to the more favorable medial and inferior columellar location. A and C, Before surgery. B and D, After surgery including revision caudal septoplasty, double dome binding, lateral crural overlay, and a columellar strut.

Figure 8. Poorly defined cantilever point. African American and Latino noses often display this type of anatomy, including thick skin, long membranous septum, retrusive maxillary spine, and weak or thin lower lateral crura. A, Before surgery. B, After surgery including multiple structural grafts with dome binding.

produce rotation; rather, a loss of projection will occur after surgery until the anterior septal angle is again supporting the tripod in a new deprojected position, regardless of whether an open or closed approach is used. This is the situation in which polybeaks most likely can occur. Unless significant nasal tip modifications— such as a columellar strut (with or without dome-binding technique) or strip division procedures (such as the modified Goldman tip)—are performed to move the cantilever point to the base of the columella, no rotation or maintenance of projection will be possible (**Figure 4**).

A less common anatomical situation is the ptotic nose with hypertrophic lateral crura, a configuration that is commonly seen in patients of Middle Eastern or Mediterranean descent but is also seen in a lesser form in many other populations. In this situation, the pivot point is the
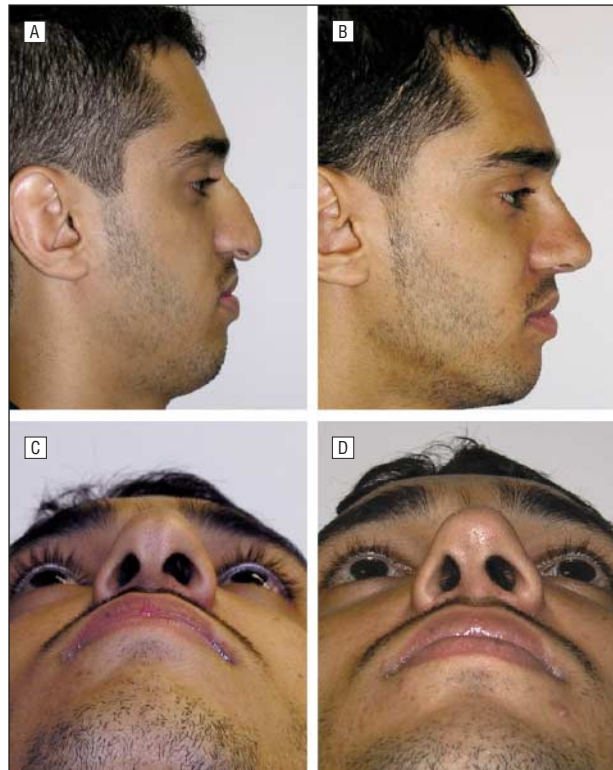
lateral crura through its sesamoid attachments to the pyriform aperture. Significant medial support is often needed to counteract the severe downward thrust of the lateral crus. This force is often reflected in the medial crura; although adequate in length on base view, they are often bowed in a state of tension that causes increased columellar show. In addition, the surgeon must overcome gravity, skin weight, crural anatomy, and other tip-depressing forces such as an overactive depressor septi muscle. Excessive thick skin with its superficial muscular aponeurotic system is an important external force acting to derotate the nasal tip in these patients ("glacier

Table 2. Anatomic or Racial/Ethnic Subcategories With Relevant Cantilever Principles

Subtype	Relevant Crual and Nasal Anatomy	Major Tip Support Mechanisms	Pivot Point	Selected Techniques for Rotation Alone	Selected Techniques for Rotation and Projection
Leptorrhine	Long medial crura, balanced tripod	Caudal septal attachments to medial crura, strength and anatomy of lower lateral cartilages	Base of columella	Cephalic trim, caudal septal trim, columellar strut	Dome-binding sutures, columellar strut
Platyrrhine	Short medial crura, weak lateral crura, long membranous septum, bimaxillary protrusion, retrusive nasal spine	Attachments to the overlying skin and superficial muscular aponeurotic system, anterior septal angle, interdomal ligament	Anterior septal angle or no definable pivot point	Columellar strut (composite)	Premaxillary implant, camouflage grafts, dome binding incorporating composite or osseous columellar strut, extended tip–columellar graft
Tension nose or dependent tip	Moderate to short medial crura, often increased caudal septal length, septal angle is high	Anterior septal angle	Anterior septal angle	Cephalic trim, caudal septal trim, columellar strut (if loss of projection is desired)	Dome-binding sutures, columellar strut (if loss of projection is desired)
Ptosis with hypertrophic lateral crura (Middle Eastern nose)	Large and long lateral crura, normal medial crura, often active depressor septum	Lateral crural attachments to the pyriform, strength of the lateral crura	Lateral crural attachments to the pyriform	Lateral crural overlay, lateral hinge	Dome binding with lateral crural steal, dome binding with composite strut, lateral crural overlay with composite strut, modified Goldman tip with composite strut

effect"). To oppose this, it is often necessary to disjoin the lateral cartilages from the central columellar segments. Creating a monopod helps to dissipate the downward vector, while simultaneously bolstering the central compartment with suturing and strut placement.

Strip division, overlay, or crural steal techniques are often required in patients with lateral crural hypertrophy.[13,14] These more aggressive maneuvers are essential because the entire tip has an overall downward force vector and is pivoting from an unfavorable cephalic and lateral-based point in the nose (**Figure 5**). Division and cartilage excision or overlap create better balance between the medial and lateral segments. This also results in a shorter cantilever beam length, with resultant increased potential energy to the tip.

Strip division techniques such as the modified Goldman tip, lateral crural overlay, and lateral crural hinge (with or without medial crural grafting) are successful in these patients because they modify the pivot point to the more favorable medial and inferior columellar location (**Figure 6** and **Figure 7**). Incomplete strip techniques separate the downward force of hypertrophied lateral crura, while decreasing overall beam length significantly. This not only greatly enhances the elastic potential energy of the medial segment but also creates a distinct central monopod unit that is separately cantilevered at the classic columellar position.

In contradistinction, the ptotic nose with weak lateral crura will not be effectively treated using strip division techniques alone. African American and Latino noses often display this type of anatomy, including thick skin, long membranous septum, retrusive maxillary spine, and

weak or thin lower lateral crura (**Figure 8**). Their pivot point is hard to identify because the tip seems to be supported by a combination of dorsal nasal septum and overlying skin–superficial muscular aponeurotic system attachments. The caudal septum cannot be the source of nasal tip cantilever support owing to the elongated membranous septum in these patients, and the anterior nasal spine is retrusive, making direct medial crural apposition unlikely.

On base view, the medial crura may or may not span the entire columella. However, they are so weak that they often bend from the weight of the nose above, causing columellar show, medial crural flare, and ptosis. This is easily confirmed on inspection of the medial crura, which are often 1 to 2 mm in width. To obtain any significant change in nasal tip appearance, substantial maneuvers are required, including dome binding, lateral crural steal,[13] vertical division techniques, and various forms of grafting such as extended columellar tip,[15] premaxillary grafts, and large columellar struts. The effect of these interventions is to produce enough strength so that a medial cantilever point is produced and tip modification can be predictably achieved using other classic techniques.

Further supporting evidence can be seen in recent and past publications on rhinoplasty techniques. Adamson and colleagues allude to the cantilever effect in their description of the M-arch model[7] and in a prior article describing the nasal hinge technique.[14] In that study,[14] patients required strong medial support, which mandated a natural or surgically created pivot point at the base of the columella. Ninety-five percent of the study patients required a columellar strut. The hinge maneuver de-
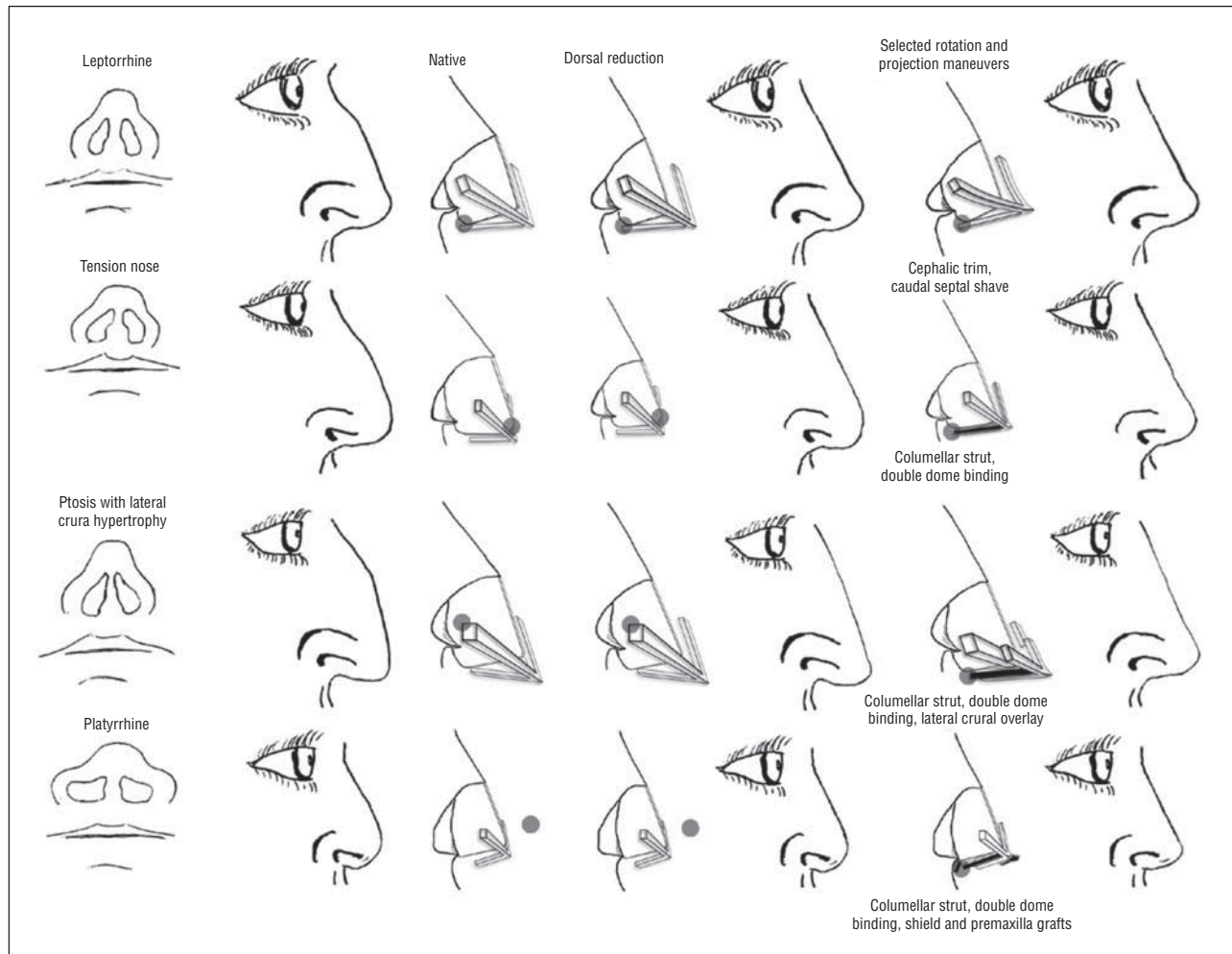
Figure 9. Clinical application of the cantilever effect. Gray circles represent cantilever point location.

creased the beam length of the cantilevered spring, increasing elastic potential energy and allowing rotation and projection to occur. The placement of a columellar strut ensured a caudal septal cantilever point, adding stability to the surgical maneuver. A similar effect is seen with the lateral crural overlay technique proposed by Kridel et al.[3] Finally, tongue-in-groove techniques[3] and caudal septal extension grafts[4] create a rigid cantilever point to ensure predictable nasal tip position after surgery but may decrease natural nasal tip movement with animation.

CONCLUSIONS

Although the cantilever effect may seem vast in scope, its clinical application is simple (**Table 2** and **Figure 9**). Essentially, any nose with a lack of medial support or overall poor tip strength will have a cephalically based pivot point, which often is the anterior septal angle or uncommonly is the lateral crural sesamoid attachments to the pyramid. Unless deprojection or derotation of the nasal tip is desired, strip division or medially based grafting is required. These 2 maneuvers are designed to displace the pivot point of the elastic tripod to a more classic position located at the base of the columella. After doing so,

more standard techniques for rotation or projection can be applied, assuming a midline caudal septum. The caudal septum seems to be the most significant foundation element for the nasal tip in most clinical scenarios, as it has been experimentally proven to have the highest elastic modulus of all the nasal tip cartilages. The only "universal" major nasal tip support element seems to be the cartilages themselves.

Deprojection can be obtained from modification of the cantilever point in patients with anterior septal angle and columellar base cantilevers. Modification of the surrounding structures that produce posterocaudal forces can also be performed in specific clinical scenarios. Among others, these include excessive caudal septal length, a pushing philtrum, and an overactive depressor septi muscle.

The application of this theory requires interpretation of the patient's underlying nasal anatomy. Many of the postulates presented herein are subjective in nature. Therefore, the surgeon must decide the strength of the medial and lateral tripod segments and the cantilever point location to correctly apply this philosophy. Inspection of the cartilages during surgery is required to make a final assessment of their strength and geometry, as this may influence the decision tree for surgical manipulation. Ex-

perience is required in this regard. However, we believe that applying the concept of the cantilevered spring can help to explain the variety of clinical interventions that are performed during aesthetic and functional rhinoplasty today.

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