

Complex minimally invasive solutions for structural changes of the nose and traumatic injuries of the skull base

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PhD Thesis

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Historical Foundations of Nasal Reconstruction Surgery

The evolution of reconstructive nasal surgery represents one of medicine's most fascinating journeys, spanning over 5,000 years of continuous development and refinement. The earliest documented nasal repairs date back to approximately 3000 BCE, as recorded in the Edwin Smith Papyrus, establishing nasal reconstruction as one of humanity's oldest surgical disciplines. Ancient Indian civilization made the most significant early contributions to this field, with foundational knowledge initially transmitted orally before being systematically documented by renowned physicians Charaka and Sushruta.

Sushruta, often regarded as the "Father of Indian surgery" and the "Father of Indian plastic surgery," authored the monumental Sushruta Samhita around 800-1000 BCE, which remains one of history's most comprehensive surgical knowledge compilations. Working likely at Banaras University, Sushruta organized medical knowledge into five comprehensive sections covering

terminology, pathology, anatomy, treatments, and toxicology, establishing foundations that continue to influence modern plastic surgery. His surgical innovations were remarkable for their time, describing 125 different surgical instruments and classifying procedures into eight distinct types: incision, excision, scarification, puncturing, probing, extraction, drainage, and suturing.

The Renaissance period witnessed a revolutionary revival of plastic surgery through the pioneering work of Gaspare Tagliacozzi (1545-1599), a professor at the University of Bologna whose contributions established him as a foundational figure in modern reconstructive surgery. His seminal publication, “De Curtorum Chirurgia per Insitionem” (1597), is considered the first book exclusively devoted to plastic surgery and introduced the “Italian method” for nasal reconstruction.

The early 20th century marked a transformative period through the contributions of Jacques Joseph (1865-1934) and Harold Delf Gillies (1882-1960). Jacques Joseph, known as “Nose Joseph,” systematized corrective, reconstructive, and aesthetic rhinoplasty through his

meticulous work in Germany, performing the first nasal reduction operation using external access in 1898 and reporting the first simultaneous intranasal correction of a protuberant nose with anterior septum correction in 1904. His comprehensive 842-page book on nasal plastic surgery, completed in 1931, represented a monumental scientific contribution that authenticated aesthetic surgery as a serious surgical specialty.

Evolution of Minimally Invasive Surgical Techniques

The origins of minimally invasive surgery can be traced to the early 1900s, when visionary pioneers including Dimitri Ott, Georg Kelling, and Hans Christian Jacobaeus began developing techniques that would eventually revolutionize surgical practice. Georg Kelling performed a procedure called “koelioscopie” in 1901, which closely resembled modern laparoscopy, while Jacobaeus published his first report of “Laparothorakoskopie” that same year. The first laparoscopy in the United States was performed by Bertram M. Bernheim in 1911, who termed his method “organoscopy”.

A critical technological breakthrough came from Hungarian physician János Veres, who introduced his insufflation needle with a spring mechanism that allowed for safer creation of pneumoperitoneum—a technique that remains fundamental to modern laparoscopic procedures. The 1960s and 1970s witnessed a revolution in optical technology that proved crucial to modern endoscopy development. Harold Hopkins' application of solid rod lenses in endoscope construction in 1966 dramatically improved image quality and illumination, while Takanori Fukushima's introduction of the neurofiberscope in 1973 opened further possibilities in neuroendoscopy.

The first nasal endoscopy attempt is credited to Hirschman in 1901, who used a modified cystoscope to examine the sinonasal cavity. Walter Messerklinger's foundational research in Graz, Austria during the 1950s and 1960s mapped mucus transport routes in the nose and developed techniques for operating in a near-bloodless field. David Kennedy's observation of Messerklinger's methods and collaboration with Karl Storz to develop

specialized instruments led to the coining of “functional endoscopic sinus surgery” (FESS) in 1984.

L-Shaped Costal Cartilage Strut Grafts for Granulomatosis with Polyangiitis

Granulomatosis with Polyangiitis (GPA), formerly known as Wegener’s granulomatosis, represents a rare, severe, and potentially life-threatening systemic autoimmune condition characterized by necrotizing inflammation affecting capillaries, arterioles, and venules. The condition primarily impacts upper airway, kidney, and lung function, with nasal mucosa involvement occurring in 90% of cases, producing the distinctive presentation referred to as “Wegener’s nose”. The inflammatory process frequently results in permanent damage to upper airway tissues, with the nasal cavity and paranasal sinuses showing the highest involvement rate at 64%-80%.

The research examined seven Caucasian individuals diagnosed with GPA who presented with severe saddle nose deformities between 2012 and 2022. This cohort consisted of two male and five female patients, with four

individuals categorized as having Daniel's classification type III deformities and three classified as type IV. All patients had previously received histopathological confirmation of their GPA diagnosis and underwent comprehensive rheumatological evaluations to establish appropriate timing for surgical intervention.

The innovative L-shaped costal cartilage strut (L-CCS) technique was specifically engineered to address limitations of previous methodologies, including graft instability and insufficient nasal tip projection. The procedure involves harvesting costal cartilage through a small incision (5-10 cm) in the submammary region at the level of the 6th-7th rib cartilage. The technique divides the rib cartilage into two distinct segments, with the longer segment providing structural reinforcement for the nasal dorsum and the shorter component delivering both support and projection for the nasal tip.

Endoscopic Management of Traumatic Brain Abscess

The research also documented a unique pediatric case that demonstrates the versatility of minimally invasive

approaches in managing complex skull base pathologies. A 22-month-old male patient was admitted following his first grand mal epileptic seizure, with a history of massive left-sided nasal bleeding two weeks prior after falling with a pencil that had reportedly penetrated the nasal cavity. Cranial MRI revealed a 35mm single abscess in the right frontal lobe near the cribriform plate, connected to the left nasal cavity by a visible canal.

The endoscopic approach utilized a 30° endoscope to visualize the left nasal cavity, revealing a white foreign object at the junction of the horizontal cribriform plate and the perpendicular lamina of the ethmoid bone. Using a 45° upward-angled Weil-Blakesley forceps, the foreign object (pencil tip) was gently extracted under continuous endoscopic visualization. Following foreign body removal, the abscess spontaneously drained through the puncture canal, and the endoscope was advanced into the abscess cavity for thorough irrigation with iodine and saline solution.

GPA Reconstruction Outcomes

The clinical results from the GPA cohort demonstrated significant improvements in both functional and aesthetic outcomes. The mean operative duration was 120 ± 10 minutes, with no intraoperative complications such as significant hemorrhage or pneumothorax. Median hospitalization lasted 5 ± 2 days, with postoperative pain assessed via visual analog scale averaging 4.5 ± 2 pre-discharge and decreasing to 2.5 ± 1 by postoperative days 7 and 14.

The Rhinoplasty Outcome Evaluation (ROE) questionnaire results showed statistically significant improvement at three-month follow-up ($p = 0.00156$, Wilcoxon rank-sum test). This validated patient-reported outcome measure, comprising questions scored on a 0–4 Likert scale, demonstrated substantial enhancement in patient satisfaction across physical, emotional, and social domains. Long-term monitoring spanning 1–10 years (mean: 60 months) confirmed durable outcomes, with sustained functional and aesthetic enhancements documented in final assessments conducted in 2023.

Pediatric Brain Abscess Management

The pediatric case demonstrated remarkable success with the minimally invasive endoscopic approach. Postoperative care was conducted in the pediatric Intensive Care Unit for 7 days, with targeted antibiotic therapy based on microbiological findings (*Klebsiella pneumoniae* and *Bacillus subtilis*) using a combination of vancomycin, rifampicin, and Rocephin administered parenterally. Laboratory values showed progressive decrease in inflammatory markers, and no seizures or neurological symptoms were observed during the treatment period.

Follow-up MRI demonstrated significant reduction in abscess size, leading to catheter removal on the seventh postoperative day. While rhino-liquorrhea was detected shortly thereafter, necessitating spinal drain placement, this was successfully managed without complications. Control MRI on the 26th postoperative day revealed complete regression of the abscess, and the patient was discharged asymptomatic with no neurological deficits maintained during one-year follow-up.

Discussion and Clinical Implications

The convergence of aesthetic and emergency interventions through minimally invasive approaches represents a transformative evolution in surgical practice that merits thorough investigation. Although GPA reconstruction and traumatic brain abscess management appear fundamentally different, both scenarios benefit remarkably from minimally invasive techniques that share core principles of reduced tissue trauma, enhanced visualization, and precise manipulation. The evolution toward minimally invasive approaches in both contexts reflects growing recognition of patient benefits including reduced postoperative pain, shorter hospital stays, faster recovery times, and improved cosmetic outcomes.

The L-CCS technique proves particularly effective for immunologically mediated saddle nose deformities, with the streamlined methodology facilitating precise graft fabrication and stabilization. Clinical outcomes reveal that substantial enhancement of nasal airflow remains challenging due to disease-specific anatomical alterations, including destruction of nasal mucosa and complete

resorption of turbinates—critical structures for airflow regulation and sensory feedback. This creates a paradoxical obstruction phenomenon where patients report persistent obstruction sensations despite surgically enlarged nasal cavities.

The transnasal endoscopic management of traumatic brain abscesses demonstrates principles that echo those guiding reconstructive techniques in immunologically mediated disorders. The approach allows for foreign object removal, abscess evacuation, and drainage in a single procedure without requiring external craniotomy, significantly reducing surgical trauma while maximizing therapeutic efficacy. Compared to traditional open approaches such as bifrontal craniotomy, frontolateral, transfrontal, or frontonasal approaches, the endoscopic technique substantially reduces infection rates and avoids substantial risks including meningitis, frontobasal CSF fistula, cranial nerve damage, and pneumocephalus.

Multidisciplinary Approach and Safety Considerations

Both surgical approaches emphasize the critical importance of multidisciplinary collaboration in achieving optimal outcomes. GPA patients benefit from coordinated rheumatological, otolaryngological, and anesthesiological expertise to optimize perioperative disease control and surgical outcomes. Similarly, the pediatric brain abscess case exemplified successful collaboration between pediatricians, otorhinolaryngologists, and neurosurgeons, resulting in comprehensive management through a single minimally invasive procedure.

Safety considerations remain paramount in both contexts. For GPA patients, infection prevention constitutes a critical priority given its role as the primary determinant of graft failure through rejection or resorption processes. Permanent immunosuppressive regimens and corticosteroid dependence may impair wound healing dynamics while increasing susceptibility to postoperative infections. In traumatic brain abscess management, strict

examination guidelines must be established regarding imaging modalities, particularly avoiding MRI until radiographic confirmation establishes that any potential foreign body is non-metallic.

Conclusions and Future Directions

This comprehensive analysis demonstrates the remarkable intersection of minimally invasive surgical approaches across diverse clinical scenarios, from aesthetic reconstruction of immunologically-mediated nasal deformities to emergency management of life-threatening intracranial complications. Both methodologies share fundamental surgical principles that transcend their immediate applications, substantiating the evolution toward minimally invasive paradigms that balance intervention necessity with iatrogenic risk minimization.

The success of these approaches confirms that less invasive techniques not only reduce immediate surgical morbidity but facilitate enhanced long-term outcomes through preservation of anatomical structures and physiological function. Technical innovations include the

simplified L-CCS graft stabilization technique, which achieves reliable outcomes while reducing operative complexity, demonstrating particular value for immunosuppressed patients where wound healing dynamics present additional challenges. Similarly, the transnasal corridor for brain abscess management represents an adaptation of established endoscopic techniques to address traumatic pathologies, demonstrating the versatility of minimally invasive approaches across diagnostic boundaries. The clinical significance extends beyond immediate surgical outcomes to broader patterns of patient management, with both techniques facilitating intervention in patients previously considered poor candidates for surgery while significantly reducing perioperative risk compared to traditional approaches. Future research should focus on larger prospective multicenter trials with standardized outcome measures to establish definitive comparative effectiveness against alternative reconstruction modalities and validate these techniques across diverse clinical environments.