Craniosynostosis surgery: the legacy of Paul Tessier

Historical vignette

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Paul Louis Tessier is recognized as the father of craniofacial surgery. While his story and pivotal contributions to the development of the multidisciplinary practice of craniofacial surgery are much highlighted in plastic surgery literature, they are seldom discussed in the context of neurosurgeons. His life and legacy to craniosynostosis and neurosurgery are explored in the present paper.

Key words • Paul Tessier • craniofacial surgery • craniosynostosis • history

The history of craniosynostosis surgery is an interesting one and has been well discussed in the recent neurosurgical literature. However, operative intervention for craniosynostosis is not a field exclusive to neurosurgeons, with one of the most important contributors to the development of modern techniques hailing from the field of plastic surgery—Paul Louis Tessier (August 1, 1917–June 6, 2008). To fully appreciate the history and evolution of craniosynostosis surgery, one must understand both Tessier’s direct contributions to this condition proper as well as his indirect contributions through the development of operative strategies employed generally in the correction of craniofacial deformities. What we now consider to be the “routine treatment” of craniosynostosis and other craniofacial pathologies is based in the many principles and methods pioneered by Tessier. To date, Tessier’s impact on neurosurgery from his work on craniosynostosis and facial trauma has not been discussed. In fact, multiple disciplines, including plastic surgery, head and neck surgery, oral-maxillofacial surgery, ophthalmology, and neurosurgery, have been deeply influenced by Paul Tessier’s work.

Background

Craniosynostosis constitutes a heterogeneous group of disorders that are the consequence of premature fusion of one or more cranial sutures. In a majority of cases, craniosynostotic disease involving a single suture is not associated with medical or neurological complications, and in these cases surgery is indicated primarily for cosmetic purposes. With multiple suture involvement, complications including, but not limited to, brain growth restriction, hydrocephalus, and blindness constitute medical indications for surgery, in addition to aesthetic restoration. Early operative intervention (in patients prior to 6 months of age) has been reported to achieve good results, but is associated with an increased incidence of reoperation. Conversely, late operative intervention less frequently requires reoperation and enables intraoperative correction, but often involves more extensive reconstruction.

Craniosynostosis is most frequently nonsyndromic and monosutural but may be associated with a known genetic disorder, such as Crouzon or Apert syndrome. The latter may involve multiple synostoses and often require more extensive and staged reconstruction. Nasal and oral airway functions are often affected in these cases.

Simple synostectomy was first performed by Lannelongue (1890) and Lane (1892). In many patients, the operation was performed late and resulted in considerable reossification, which led to reestablishment of brain growth restriction. Moreover, in an early case series of 33 patients, Jacobi (1894) reported a high operative mortality rate (15 deaths). The high failure rate and mortality burden in these early cases had two possible antecedents:

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Abbreviation used in this paper: CFD = craniofacial dysostosis.
1) microcephaly was misdiagnosed as craniosynostosis or 2) the surgery was performed late; they were possibly less associated with a high surgical risk itself.7,8 These early surgical techniques were less than ideal, rarely achieving a satisfactory cosmetic outcome in patients with craniosynostosis. More severely affected patients, such as those with craniofacial dysostosis (CFD), were simply left untreated, being deemed “inoperable.”

Early Life and Training

Paul Tessier was born in 1917 to Ernest and Solange Tessier, who hailed from a line of wine merchants in a small town, Héric, near Nantes, France. Originally, Tessier aspired to work in forestry or join the navy but was prevented by poor health. Perhaps spurred by his mother’s battle with tuberculosis, he instead pursued a career in medicine. He attended medical school in Nantes from 1936 to 1943. During the German occupation of France in World War II, his training was interrupted by military service. In 1941, he was taken as a prisoner of war.41 A year later, his professor in infectious diseases found him to be critically ill with typhoid myocarditis and convinced his captors to release him. He returned to Nantes and finished medical school, only for his hometown to be destroyed in a bombing raid the following year. He ventured north, to Paris, to continue his surgical residency and pursue his newfound interest in cleft palate and plastic surgery (Figs. 1 and 2).21,43

Early Career

His first appointment in Paris was with Maurice Virenique, a maxillofacial surgeon. They worked together at the Red Cross military hospital and moved to Hôpital Foch,21 where Tessier gained tremendous experience in treating facial injuries at the Maxillofacial and Burn Center. Then he moved to the pediatric surgery service at Hôpital St. Joseph and worked with George Huc (a prominent orthopedist); he gained exposure to plastic surgery and orthopedics. When Virenique died, Tessier was named chief of plastic surgery at Hôpital Foch. By this time, he had gained experiences in general surgery, pediatric orthopedics, and otorhinolaryngology.43 Still, he sought to enhance his training further. Between 1946 and 1950, he made frequent trips to the United Kingdom, for 1–2 months at a time, to observe clinical practice and techniques of the surgical masters who practiced there.21,43 He sought out Sir Harold Gillies, an otolaryngologist based in London, who is arguably considered the father of plastic surgery. Gillies performed the first maxillary osteotomies on a patient with Crouzon syndrome,11 one of the congenital facial syndromes that would later become the cornerstone of Tessier’s career.25 During his many visits, he observed, performed surgery, took copious notes, and developed a strong basis in the fundamentals of craniofacial surgery. At that time, rapid advances in plastic surgery were occurring in response to severe wartime injuries. Tessier described his experiences with plastic surgery pioneers Sir Harold Gillies and Sir Archibald McIndoe as “a revelation.”21

Tessier was influenced greatly by his own unique set of multidisciplinary training and by individual mentors who were giants in each of those fields. In his inaugural address to the International Society of Craniofacial Surgery in 1985, he credited his training (and collaborators) in pediatric orthopedics (G. Huc),43 facial trauma (M. Virenique), facial reconstruction (H. Gillies, A. McIndoe), ophthalmology (G. Sourdille, P. Francois), cleft palate surgery (P. Petit), and neurosurgery (G. Guiot, J. Rougerie).24 This wide range of training was not set up for Tessier in any formal manner—he sought it out.43

After Tessier began to establish himself on the national level as a master of craniofacial pathology, he was consulted in 1957 about a patient with facial deformity of an extreme nature—a young man with Crouzon syndrome, presenting with severe facial retrusion. The operation he sought to perform had been previously tried by his mentor Gillies, who had undertaken the first Le Fort III osteotomy in 1950 to correct the same deformity. However, the newly positioned bone relapsed, and Gillies did not attempt the surgery again. Gillies commented “never to do it”11,21,25,44 and had deemed the condition inoperable.
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Tessier suspected that the application of multiple autogenous bone grafts would make the repositioned construct more stable.

Tessier wished to study on cadaver skulls and master the cranial and facial anatomy prior to attempting any intervention. Parisian medical schools denied him access to an anatomy room in the city as he had not attended school there. Thus, he and his loyal scrub nurse Micheline Huguenin would take the train to Nantes, 500 miles away, to practice the operation in the anatomy lab at his old medical school. They would return to Paris on the 2:30 AM train and be at work a few hours later. The preparatory work proved worthwhile. Tessier achieved a successful result with his novel surgery, advancing his patient’s face by 25 mm. Because of a historic dispute at his hospital, Tessier did not have access to splints, which were thought to be necessary for stabilizing the facial skeleton; Tessier’s method obviated the need for such alloplastic materials such as silicone and acrylic implants.

In addition to working with cadaver skulls with normal anatomy, Tessier realized that he needed to study abnormal skulls to fully understand and visualize the necessary corrections. He continued his search for the perfect anatomical specimen for study and operative preparation throughout his career, which also sparked his later foray into 3D image reconstruction and radiology.

It seemed he had the perfect constellation of training to be able to teach himself about craniofacial deformities and their treatment. He became familiar with intracranial and extracranial approaches for these syndromes; however it was not until he found a team of enthusiastic collaborators at Hôpital Foch that he saw a turnaround in his outcomes.

In 1963, Tessier approached Gérard Guiot, a young neurosurgeon working at the same Hôpital Foch, in Paris. Guiot and Tessier had collaborated previously on reconstruction of the orbital roof following resection of sphenoid ridge meningiomas. They had a famed meeting when Tessier was developing an approach for correction of severe teleorbitism. After much deliberation, Tessier had determined that the only way to achieve sufficient correction would be through an intracranial frontal approach to the midface and interorbital region. Guiot, his feet up on his desk, looked up at the ceiling for a moment, then replied: “Pourquoi pas?” (Why not?) (personal communication, S. A. Wolfe, December 31, 2013). This rhetorical question captured the spirit of Tessier’s innovative development of craniofacial surgery and later became the motto of the International Society of Craniofacial Surgery.

This answer shattered the wall that existed between the cranial region and the face, and between neurosurgeons and plastic surgeons, and opened up the way for the development of a constructive collaboration.

Their boldness was complemented by thoroughness; prior to attempting the procedure, Tessier and Guiot planned every step, anticipated every potential complication, and practiced on cadavers for well over a year. Together, they achieved a result that would have had been impossible in any other hands. Between this case and others, over the next several years, they developed a technique for an intracranial extradural dissection of the region, up to the optic canals, and used a dural graft for dural reinforcement.

For over 3 years, Tessier and Guiot worked to hone their technique and improve the cosmetic/aesthetic outcome for their patients, who had been given no chance previously. In 1967, their new techniques were showcased at the International Meeting of Plastic Surgery in Rome. Tessier’s presentation was extremely well received, and thus the field of craniofacial surgery was recognized.

While Guiot is mentioned in the plastic surgery literature for his famous quote, “Pourquoi pas?”, many of his contributions to the technique that he developed alongside Tessier are not always highlighted. The trio of Tessier, Guiot, and Jacques Rougerie published their extensive experience in the French- and English-language literature, describing their technical advancements in transcranial approaches for facial malformations and solutions to the challenges associated with this approach. Subsequently, the younger Patrick Derome joined the group and became Tessier’s primary neurosurgical collaborator. Derome and Rougerie continued to work very closely with Tessier, as his practice transitioned away from Hôpital Foch and to Clinique Belvedere (personal communication, S. A. Wolfe, December 31, 2013), while Guiot stayed at Foch and continued pursuing his broad interests in skull base, pituitary, stereotactic, and functional neurosurgery. Guiot and Tessier coauthored 6 papers together, of which 4 were craniofacial related and 2 were skull base related. It is likely because of his intimate knowledge of the skull base anatomy and technique that he was able to collaborate so well with Tessier on innovative craniofacial surgery. Tessier made the development of craniofacial surgery his full-time passion and career, while Guiot continued pursuing the rest of neurosurgery, in addition to operating with Tessier in craniofacial procedures. Guiot continued writing prolifically in neurosurgery, mainly about pituitary and movement disorder surgery, until the early 1980s, ultimately retiring with nearly 300 publications.

In 1969, Tessier and Guiot co-chaired a symposium...
at Hôpital Foch on various topics in craniofacial surgery. This was a joint venture describing their work over the preceding 6 years, covering neurosurgical interests (for example, encephaloceles, anterior skull base tumors, CSF leak repair, and craniotomy approach for hypertelorism) and plastic surgical ones (for example, craniofacial osteotomies, facial dysmorphism, posttraumatic deformities, and orbitocranial trauma). At the meeting, to which 60 ophthalmologists, plastic surgeons, maxillofacial surgeons, and neurosurgeons were personally invited, there were live surgical demonstrations, critiques, and lively discussions.

Tessier was interested in breaking barriers among specialties throughout his career, and frequently invited pediatricians, radiologists, plastic surgeons, maxillofacial surgeons, and neurosurgeons to his courses and symposia (Fig. 3). He traveled frequently to nurture these relationships, to large centers in the United States, England, and around France. His urge to contribute was based in his philosophy that “no one man could master all techniques and be an island unto himself.” It is widely recognized that most craniofacial surgeons in the US are deeply influenced, either directly or indirectly, by Tessier and can trace their educational lineage back to Tessier in some form.

During the late 1960s and the 1970s, Tessier developed the procedures and foundations of craniofacial surgery: transcranial and subcranial correction of orbital dystopias such as orbital hypertelorism, correction of the facial deformity of CFD (for example, Treacher Collins–Franceschetti syndrome, Crouzon syndrome, and Apert syndrome), and correction of oro-ocular clefts.

Advancements in Working With Bone

In applying to the facial skeleton standard orthopedic principles—osteotomies, bone grafting, and direct correction of deformities—Tessier revolutionized craniofacial surgery as it is practiced today. The use of these techniques in conjunction with combined extracranial and intracranial approaches permitted surgical procedures that were not previously possible.

Tessier emphasized the importance of being able to harvest autogenous bone grafts, such as those from the rib, iliac crest, or calvaria. As an example, calvarial autografting has proven to be an instrumental technique, with a plethora of applications, in craniofacial reconstructive surgery. In general, the calvarial autograft is harvested. The use of inner table calvaria results in better preservation of skull contour. Thus, in the case of a concurrent craniotomy, the inner table is harvested ex vivo and the remaining outer table replaced and secured using wires or, later, miniplates.

Tessier was not only conversant with bone graft harvesting: He also developed an array of instruments to bend and shape bone grafts into any form and shape (Fig. 4). His use of autogenous bone grafts to prevent relapse associated with precise osteotomies has tremendously enhanced the durability of reconstructions. He originally used bone grafts to treat a patient with midfacial retrusion but also successfully applied the same technique in frontonasal and frontal encephalocele and in cases of cleft lip with communication of the orbit, maxilla, and oral cavity, among many others. The combination of extracranial and intracranial approaches in the same procedure proved instrumental in many of the surgical improvements credited to him and has greatly improved the treatment of craniosynostosis. Tessier strived for craniofacial surgeons to “feel just as comfortable with bone as we are with soft tissue.”

Crouzon and Apert Syndromes

Tessier is best known for his work on CFD, specifically Crouzon and Apert syndromes. The techniques he developed for treating CFD were then applied to many other pathologies in the world of plastic and reconstructive surgery, such as restorations after trauma or tumor resection.

Prior to Tessier, the treatment of craniosynostosis, especially the syndromic variety, was largely rudimentary and there remained much room for improvement. This created the perfect niche for Tessier after the completion of his training. As described earlier, older children with craniosynostotic disease may need more extensive craniofacial reconstruction, and Tessier’s contributions have mainly improved the management of complicated forms of the disease, including those in patients exhibiting multiple suture involvement and in patients with CFD. Whereas contemporaries sought to achieve a near-normal appearance, Tessier more significantly underscored the importance of the aesthetic outcome and always aimed to achieve normality.

Historically, the treatment of the craniosynostotic disease proper in CFD was still associated with facial deformities. Consequently, Tessier emphasized the need for an optimal cosmetic outcome and, to this end, introduced advancement of the forehead and supraorbital rim. Originally developed as a more extensive coronal synostectomy, Tessier further modified the procedure by...
fixing the forehead only to the face and not the remainder of the posteriorly related calvaria. This permits cranial vault expansion and brain growth to advance the forehead, achieving a more optimal cosmetic outcome.

Tessier carefully studied timing of surgeries and identified that the growth of the midface, orbits, and anterior skull base were closely related. Specifically related to neurosurgery and craniosynostosis, CFD presented extreme cases of faciosynostosis associated with brachycephaly or oxycephaly. Without the challenge of the hypertelorism associated with a severe case of Crouzon syndrome, Tessier may have never been “simply obliged” to collaborate with Guiot for their novel approach.

Tessier’s solution for CFD, as described in his initial 14 cases in 1967 and 35 more in 1971, was radical, yet based in well-established orthopedic principles he had learned from George Huc. In one paper, he even makes a reference to “cranio-facial orthopedic surgery.” In short, it involved making osteotomies that would reproduce a facial disjunction, between the pterygoid and maxilla. He varied slightly the cuts that Gillies made in his failed operation, but the novelty of Tessier’s solution was the application of multiple bone grafts and postoperative fixation to allow stabilization.

The operative approach employs osteotomy of the entire middle third of the face, with cuts of the zygoma and orbits along with interpterygoidomyaxillary disjunction. Osteotomies of the ethmoid, posterior maxilla, and vomer are also performed. He inserted bone grafts into the zygomatic/malar step cuts, the frontomalar gap, and glabellar area, with reattachment of the middle third of the face. This procedure achieves anterior translation of the face and proper dental occlusion.

He was unhappy with the results obtained with the Le Fort III in Crouzon and Apert patients (namely, retrusive foreheads and overly long noses). He instead preferred intracranial monobloc procedures, since these resulted in normal faces in most cases. This represents the departure from the limit of maxillofacial surgery (Le Fort III) and the foray into true craniofacial surgery.

In addition to the novel surgical principles, another remarkable feature of Tessier’s publications was their thoroughness—replete with preoperative and postoperative sketches and accompanied by plenty of patient photographs (Fig. 5). He also included many recommendations on intraoperative planning and postoperative care. His training by world experts from a variety of disciplines and his “team approach” philosophy allowed him to get excellent exposure for his osteotomies from close collaborations with the Foch neurosurgeons—Guiot.
Rougerie, and Derome. This, in addition to his many courses and live demonstrations in Paris in the years to come, allowed the widespread dissemination of the principles of craniofacial surgery.

### Application of Craniofacial Surgery to Other Conditions

Prior to Tessier, the core principle applied in the treatment of facial fractures was attachment to the nearest intact superior structure, with stabilization achieved by wiring. Tessier’s introduction of bone grafts to the treatment of facial fractures revolutionized the management of congenital and acquired craniofacial disorders alike and has impacted multiple related surgical subspecialties. His contributions to the treatment of facial fractures are many, and a comprehensive discussion is beyond the scope of this review. In brief, Tessier pioneered subperiosteal dissection, which, by allowing direct interosseous osteosynthesis using wire and miniplates, obviated the need for external fixators. Improved primary stabilization also avoided the need for intermaxillary fixation and in turn tracheostomy.

Having an insightful understanding in ophthalmology, Tessier was able to make significant contributions to the treatment of orbital disease. He treated enophthalmos by reconstruction of the orbit and obturation of the inferior orbital fissure, and he was the first to pioneer use of a transcranial approach to correct global dystopias via orbital repositioning. Tessier also developed a transnasal approach to perform medial canthopexy in the treatment of posttraumatic telecanthus and was the first surgeon to place a bone graft in the orbital cavity. Lastly, Tessier is known to have been the first surgeon to spare the temporalis muscle and to use a more posteriorly placed coronal incision at the vertex rather than the anterior hairline, techniques that are currently common practice in neurological and craniofacial surgery (personal communication, S. A. Wolfe, December 8, 2013).

### Legacy

As the founding father of the specialty, Tessier’s personal approach to craniofacial surgery came to define the philosophy of a whole new generation of surgeons. He emphasized the importance of learning from each case, the work ethic required to succeed in solving the challenges of the field, and the importance of collaboration within the “craniofacial team.” This included physicians and nurses, as well as long-time scrub nurse Elizabeth Motel-Hecht, and served as a prime example of how close interaction between members of the operating team can make complex operations proceed smoothly. Many of Tessier’s protégés describe him as the founding father in the same manner that Cushing’s trainees tracked their lineage back to him. There are more than a few similarities that stand out in reading descriptions of Cushing and Tessier—the thoroughness of their physical examination, obsessive attention to detail, multidisciplinary training, and experience in treating trauma during war. A quote

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**Fig. 5.** Transcranial monobloc frontofacial advancement for treatment of Crouzon and Apert syndromes. This technique was developed by Tessier in the early 1980s. 

**A:** Schematic diagram demonstrating expansion of the frontal bandeau, providing a fixed structure to which the advanced midface and frontal bones can be attached. 

**B–E:** Lateral and frontal views of a patient with Crouzon syndrome before (B and C) and after (D and E) monobloc frontofacial advancement. The surgery restores normal cosmesis, which would have otherwise not been possible with the older technique utilizing a Le Fort III osteotomy. Reproduced with permission from A Man from Héric: The Life and Work of Paul Tessier, MD, Father of Craniofacial Surgery. Figures 10.7 and 10.8. Copyright S. Anthony Wolfe.
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from Tessier’s opening address in 1985 may have come from either: “Do not only work hard; do not work for 5 or 10 years on a problem; and do not work continuously on a problem. My advice is hard continuous work for 30 years.”43 Tessier’s experience spanned nearly 50 years (1946–1996) and 9500 procedures.39

While others before him had managed some treatment of craniosynostosis and other craniofacial deformities, what made Tessier stand out most was his stubbornness that “If it’s not normal it’s not enough.”14

Beyond working assiduously in the clinical realm, he aggressively pursued various hobbies. When told to relax after his bout of grave illness from myocarditis, he took up rowing.21 He was also known to be an active racecar driver, scuba diver, and avid safari hunter.43

As has been said about him, “Paul Tessier was courageous, noble, and wise, a French trilogy of Sir Lancelot, Ambroise Paré, and Louis Pasteur reborn in a single modern man. Just as he taught by example, he also led by it.”28

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The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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