



# Shedding light in otolaryngology: A brief history on the surgical tools of visualization and access

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## Abstract

Visualization and access. Historically, these have been the two major factors that have limited advancement in the field of Otolaryngology. No other surgical specialty deals with anatomical challenges quite like those presented by the structures of the head and neck. Otolaryngology is a field of dark cavities, complex and miniscule structures, and awkward angles. The aim of this article is to briefly explore how Otolaryngologists have historically met these challenges, with a specific focus on technological advancements in illumination, visualization, and access. From mirrors reflecting candlelight to fiberoptic illuminated scopes, from bamboo nasal speculums to Transoral Robotic Surgery (TORS), tracing the historical arc of these technologies highlights the innovative spirit that has come to define the field of Otolaryngology.

## KEYWORDS

Access, history of medicine, illumination, otolaryngology, surgical tools, visualization

## INTRODUCTION: INSPIRED BY KNOWLEDGE, LIMITED BY TECHNOLOGY

In the United States, Otolaryngology is comparatively young as an officially recognized specialty. The first organized meeting did not occur until 1896 when Dr. Hal Foster sent 500 invitations to selected physicians across the United States to attend the first ever meeting of the "Western Society of Eye, Ear, Nose, and Throat Surgeons" held in Kansas City, Mo. The name of the society was later changed to "The American Academy of Ophthalmology and Otolaryngology" in 1903 and would eventually split and evolve into the American Academy of Otolaryngology-Head and Neck Surgery that we know today.<sup>1</sup> Although young as a formally defined specialty in America, historical evidence gestures towards the field's ancient and global origins.

Archeological digs across the Middle East suggest that surgeons were designing otological tools as early as 1300 B.C. with fine hollow aural scoops found at excavation sites in Greece.<sup>2</sup> A Hindu document entitled "Suchruta-samhita", dating to the 6<sup>th</sup> century B.C. provides

the first known recording of nasal examinations via a tubular nasal speculum crafted from Bamboo shoots.<sup>3-5</sup> Texts from the Byzantine era (324-1453 A.D.) provide examples of treatises on diagnosis and treatment of ear conditions, including descriptions of surgical instruments and operative technique.<sup>6</sup> One particularly fascinating operation involved the removal of stubborn foreign bodies from the ear canal by making a post-auricular semilunar incision in order to gain better access—all completed without anesthetic or modern lighting.<sup>6</sup> All these pieces of historical evidence share one feature in common: the problem of visualization and access to Otolaryngology anatomy. The early nasal speculum and the post-auricular semilunar incision are both techniques designed to reach difficult to access anatomy, the ancient aural scoop—with its slim long hollow handle—enabled the early otologist both to access the ear canal and also, feasibly, to deliver medicative drops down the hollow tube.<sup>2</sup>

For the vast majority of history, knowledge of the anatomical structures and physiology has outstripped the Otolaryngology surgeon's ability to adequately access those structures in the living

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patient. Most are familiar with the ancient Egyptian practice of removing the brain through the nose, a part of the mummification process that indicated a basic understanding of skull base anatomy.<sup>5</sup> As early as 1489, Leonardo da Vinci was sketching anatomically correct depictions of the nasal conchae, paranasal sinuses, and of the larynx, even proposing correct mechanistic theories for laryngeal function. These sketches and proposals were based on dozens of cadaver dissections.<sup>5,7</sup> Similarly, at the famous University of Padua in Italy in 1543, the anatomist Versalio was one of the first to document the structures of the middle ear—detailing the oval and round windows as well as the malleus and the incus.<sup>7,8</sup> In these early days (and for obvious reasons) complete visualization of ear, nose, and throat anatomy was practically impossible in the living patient. This did not deter early surgeons—descriptions exist of techniques for nasal polyp removal in Hindu, Greek, and Egyptian texts dating back thousands of years; rudimentary (and admittedly deadly) laryngectomies were attempted as early as 1545; and, as previously noted, primitive ear surgeries were not uncommon procedures in the Byzantine era.<sup>5-7,9</sup> But, to a greater degree than in many other surgical specialties, the barrier to advancement in otolaryngology has been the inability to directly examine and access the anatomy in a living patient. It is a field in which progress has not been limited by physiological understanding, but rather by the pace of technological advancement.

## LIGHTING THE WAY: FROM CANDLELIGHT TO FIBEROPTIC ILLUMINATION

Imagine sunlight, focused through a flask of water and projected into the nares of your patient. This is the method Tulio Caesare Aranzi developed in 1585 in one of the first endoscopic examinations of the nasal cavity ever documented.<sup>10</sup> For the next four hundred years, early Otolaryngologists, physicists, and (surprisingly) musicians designed and tinkered, attempting—like Aranzi—to tame light and direct it into the facial cavities of living patients. In 1743 the French surgeon, Andre Levret, designed an angled mirror that allowed him to visualize and ligate antrochoanal polyps in the nose; in 1789 Archibald Cleland, an English army surgeon, used a candle connected to a biconvex lens to direct rays of light down any body cavity that could be brought into a straight line—these devices were useful for simple rhinoscopy and otoscopy, but not as useful for visualizing the more angled anatomy of the larynx.<sup>10</sup>

Enter the “Lightleiter,” or light conductor, introduced in Germany in 1806 by Dr. Philipp Bozzini. The first internally lit device used to inspect cavities of the human body, the Lightleiter included a candle and a series of angled mirrors placed within a tube, allowing light to be reflected around corners. Initially devised for examining the larynx, the design was rapidly adapted for urologic and gynecologic applications, transforming those fields as well and earning Dr. Bozzini the title “Father of Endoscopy.”<sup>7,10,11</sup> The Lightleiter heralded a century of rapid advancement in illumination in Otolaryngology as innovators toyed with angled mirrors and newly understood theories of physics.

Still, the larynx remained elusive. In 1825, French physicist Cagniard de la Tour attempted to use two mirrors to visualize

laryngeal function—unfortunately he only managed a glottic view. Similarly, in 1829, Dr. Benjamin Ebbington presented the “glottiscope,” composed of a tongue retractor connected to an oblong mirror—sunlight from behind a seated patient would be reflected by a simple mirror held in one hand and towards the glottiscope mirror held in the other hand, allowing glottic visualization.<sup>7</sup> It wasn't until Manuel Garcia, a Spanish Music Professor, used a dental mirror to examine his own larynx during vocalization that the vocal cords were first visualized in vivo.<sup>7</sup> His designs were adapted by physicians across Europe in the development of more modern “laryngoscopes” as well as inspiring advances in rhinoscopy. The majority of these developments were still dependent on natural lighting—some European physicians reported that laryngeal pathologies could only effectively be observed during the spring and summer when the brighter sunlight allowed it.<sup>7,12</sup>

In 1841, Dr. Friedrich Hofmann developed the concave head mirror that would come to define the modern Otolaryngologist. With a central hole which allowed light to be focused into the external auditory canal, the mirror enabled Dr. Hoffman to visualize the tympanic membrane. It revolutionized the field, affording co-axial vision through reflected light and maintaining binocular vision through the uncovered eye—over the next 20 years this simple design was improved, frontal bands were added and revised, but the basic concept remains largely unchanged and has been utilized by physicians well into the 21<sup>st</sup> century to peer into obscure cavities.<sup>10</sup>

In 1853, nearly 40 years after the original Leightleiter, Dr. Antonie Jean Desomeaux modified Bozzini's design, replacing candlelight with a lamp burning alcohol and turpentine and adding condensers that projected light beams down the tube. This device was smaller, less unwieldy, and offered improved illumination than its predecessor, allowing surgeons to use smaller specula and perform more advanced operative endoscopic procedures (mostly on the urethras and bladders) of living patients.<sup>10</sup> The trend toward smaller more controllable tubes and better illumination would continue to define technological advances in Otolaryngology for the next century.

From Dr. Bozzini's primitive endoscope, designed originally for the larynx and ultimately used for genitourinary examinations, to Dr. Maximilian Nitze's 1879 cystoscope, which was adopted by Dr. Hirschman in 1901 to visualize the maxillary sinus, quests to explore the hidden anatomies of Otolaryngology and Urology have bolstered and inspired advances in each field.<sup>13</sup> Dr. Hirschman's modified cystoscope used a small electric bulb and was primarily diagnostic, visualizing the maxillary sinus through an oroantral fistula.<sup>14</sup> This transition from flame to electric bulb was another defining moment in the history of Otolaryngology. One early Otolaryngologist, Dr. Francis Packard, practicing at the turn of the century at the Pennsylvania Hospital reflects back on this marvelous transition in light in laryngoscopy: “Our source of illumination was usually gas, and in the dark, crowded rooms of the clinic the heat given off by the lights at the three or four tables created a most disagreeable atmosphere, and the illumination by reflected gas light was much less satisfactory than that afforded later by powerful electric light.”<sup>15</sup>

These advances in illumination ushered in a century of even more rapid change in the field. By the 1930s, John Baird, inventor of the television, proposed transmitting images through flexible glass fibers, inspiring Dr. Harold Hopkins in London to invent rod-optic endoscopes in 1948.<sup>5,7,14</sup> The age of fiberoptics had arrived and the fields of Laryngology and Rhinology were transformed. The Hopkins scope was quickly altered by Karl Storz in Germany who built endoscopes with angled views from 0° to 30°, 70°, 90°, and 120°, finally successfully overcoming the challenge of awkward angles in the sinus.<sup>14</sup> By the 1950s, the use otologic microscopes had been well-established (the first documented use of a microscope for ear surgery occurred in 1921 by Swedish otologist Carl Olof Nylen), allowing increased access to the ear canal and transforming otology as a field—the delicate structures of the middle and inner ear could now be manipulated.<sup>7,9,16</sup> These operating microscopes were introduced to sinus surgery in the 1970s but only provided a limited binocular view through a nasal speculum; many surgeons found this disorienting and the use of these microscopes for sinus surgery was never widely utilized.<sup>17</sup>

Other technologies emerging in the past century include the radiograph and more recently advances in camera and video technology, further transforming the field. Radiographs were first produced in Europe in the late 1800s; by the 1920s they were standard of practice in diagnosing sinus disease in the United States.<sup>9</sup> With the introduction of computed tomography (CT) in 1969 by Geoffrey Hounsfield,<sup>7</sup> the last 50 years have seen a dramatic improvement in the surgeon's ability to appreciate and treat disease states of the paranasal sinus anatomy.<sup>17</sup>

## ILLUMINATION GRANTS ACCESS: FIELD DEFINED BY MODERN TECHNOLOGY

With visualization came access. Modern-day Otolaryngologists are defined by the technology of their trade – the otologist and the microscope, the rhinologist and the endoscope, the laryngologist and the laryngoscope, and most recently, the head and neck oncologic surgeon and the da Vinci robot. But, as evidenced through historical documentation, surgery in Otolaryngology did not wait on visualization! In rhinology, prior to introduction of the endoscope, physicians blindly accessed the sinuses, conducting headlight illuminated intranasal ethmoidectomies. In the late 1800s, external trephination of the frontal sinus was the primary method of treating frontal sinus disease; more aggressive external approaches involved the obliteration of the frontal wall of the sinus, resulting in expected cosmetic defects.<sup>9</sup> Maxillary sinus surgery didn't fare much better, with early techniques involving removal of a molar to gain access through the alveolus.<sup>9</sup> Throughout the 19<sup>th</sup> and 20<sup>th</sup> centuries, surgeons vacillated between this external approach to rhinology and blind intranasal approaches, both techniques dangerous and with poor outcomes. One surgeon, writing in 1929, reported that the intranasal ethmoidectomy “proved to be one of the easiest operations with which to kill a patient”.<sup>9,18</sup> But by the 1980s, the

endoscopes originally designed by Dr. Hopkins meant that intranasal ethmoidectomies could be conducted safely and effectively. The invention of the 45-degree scope in the last 20 years has made even the mysterious frontal sinus safely accessible.<sup>9,11</sup> Not only have these technologies revolutionized Otolaryngology, but Neurosurgery as well, enabling transsphenoidal approaches to the skull base.

Using the rod optic endoscope system, surgeons like Dr. Messerklinger, Dr. Wolfgang Draf, and Dr. Wigand developed surgical sinus procedures that limited surgery to areas of most significant disease. The first course in Functional Endoscopic Sinus Surgery (FESS) was held at Johns Hopkins in 1985, led by Dr. David Kennedy, Dr. Heinz Stammberger, and Dr. James Zinreich.<sup>17</sup> These pioneers transformed the field with FESS, which allowed the surgeon to open the nasal passages while preserving nasal function. Dr. Kennedy also realized the importance of CT scans in these planning of these procedures, and thanks to advances in the last two decades we are now witnessing the development of 3D telescopes and interactive imaging.<sup>10,17</sup>

One of the most dramatic transformations in accessibility for the Otolaryngology surgeon is the recent development of Transoral Robotic Surgery (TORS) for oropharyngeal tumor resection. The first recorded complete glossectomy to remove a tumor of a tongue was attempted in 1664 in Italy at the University of Padua, and the surgeon controlled the bleeding with cauterization.<sup>4</sup> For centuries, head and neck surgeries (specifically those of the oropharynx), were slow to develop given the difficulties associated with airway management, hemorrhage, and lack of anesthesia. But with modern anesthesia came surgical advances to meet these challenges—base of tongue surgeries have become common procedures for the Head and Neck Surgeon. Traditionally, these oropharyngeal tumors have been resected via an open approach frequently requiring a midline mandibulotomy—procedures of ultimate anatomical access, but quite invasive. In the early 2000s, Dr. Gregory Weinstein and Dr. Bert O'Malley successfully demonstrated how the Da Vinci Surgical System, a robotic system approved by the FDA in 2000 for minimally invasive surgeries, could be utilized for the oropharyngeal cancer resections, eliminating the need for the dramatic mandibulotomy in many patients.<sup>19</sup> Results were clear: lower estimated blood loss, shorter hospital stays, and fewer complications.<sup>20</sup>

## CONCLUSION

By necessity, Otolaryngology is a specialty of innovators. This is a field of tools. Of technology. And over the last century it is clear that we have come a long way from candlelight and nasal speculums made from bamboo. But as the field takes its next steps forward, it is useful to reflect back on some of the major innovations and historical advancements that have enabled Otolaryngology to develop into the specialty it is today. Understanding this history may serve to inspire future innovations and remind us of how new technologies, large and small, can completely transform a field of medical practice.

## CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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