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The Netherlands

Laser tonsil treatment under local anesthesia: a patient-friendly effective alternative?

Wong Chung, J.E.R.E.

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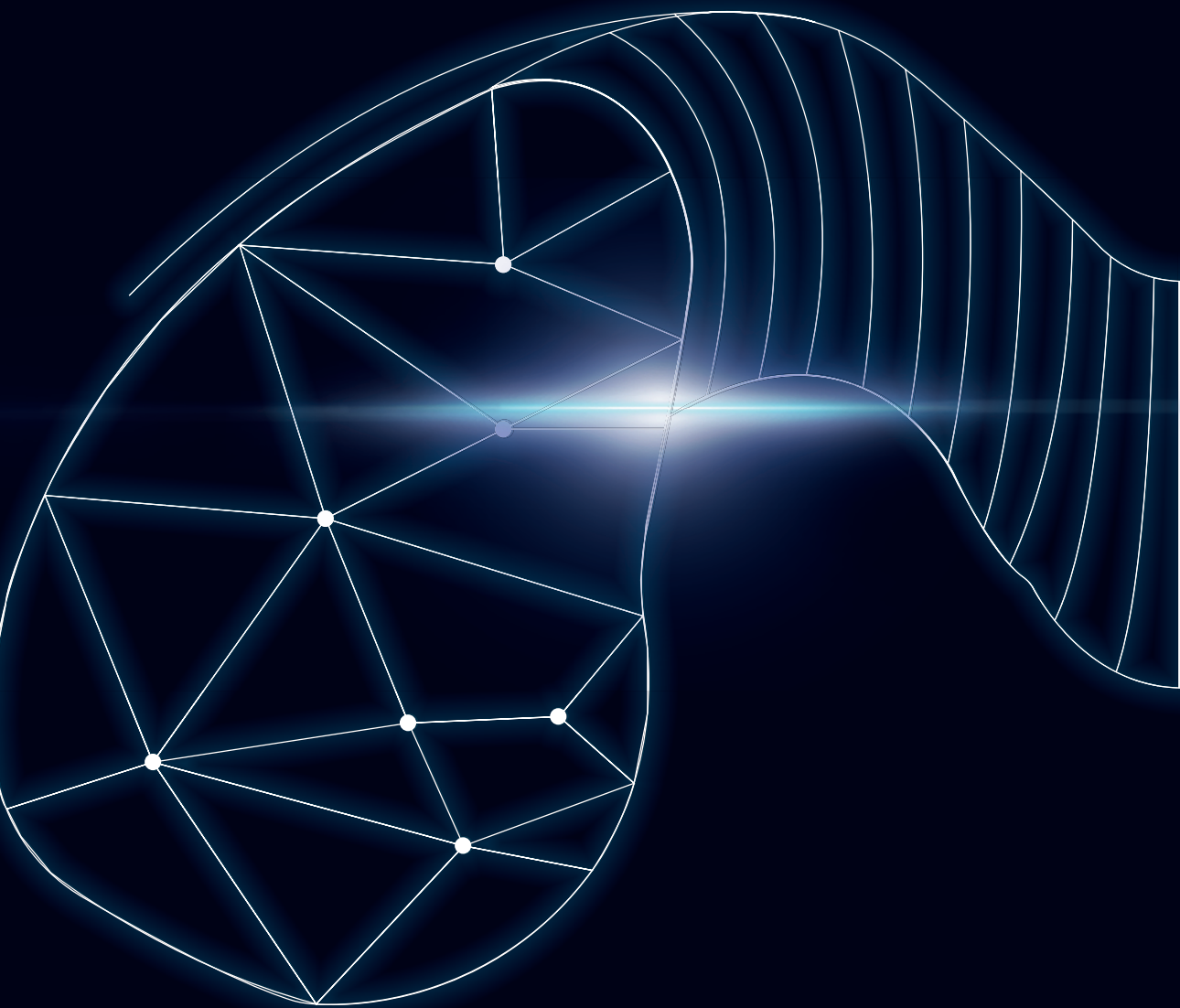
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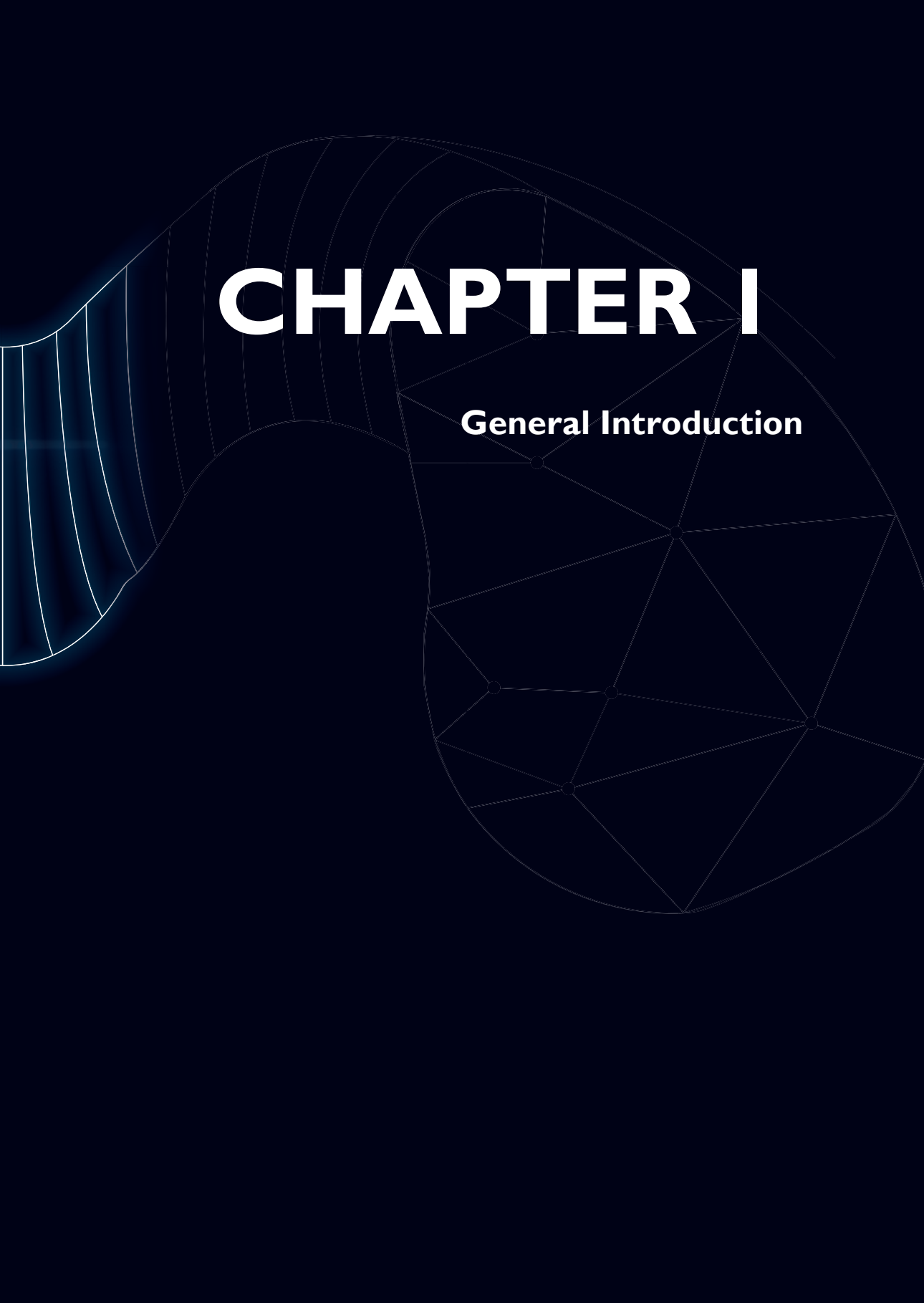
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CHAPTER I

General Introduction

PALATINE TONSILS: ANATOMY AND FUNCTION

The palatine tonsils are two lymphoid structures located in the tonsillar sinus, positioned between the palatoglossal and palatopharyngeal arches. The **palatoglossal muscle** forms the anterior pillar, while the **palatopharyngeal muscle** forms the posterior pillar (**Figure 1**). Each tonsil has a medial surface with up to 15 crypts, increasing antigen exposure, and a lateral surface encapsulated by superior pharyngobasilar fascia and loose areolar tissue. This capsule adheres tightly to the tonsil and extends inward as septa containing nerves, blood vessels, and lymphatic vessels.^{1,2}

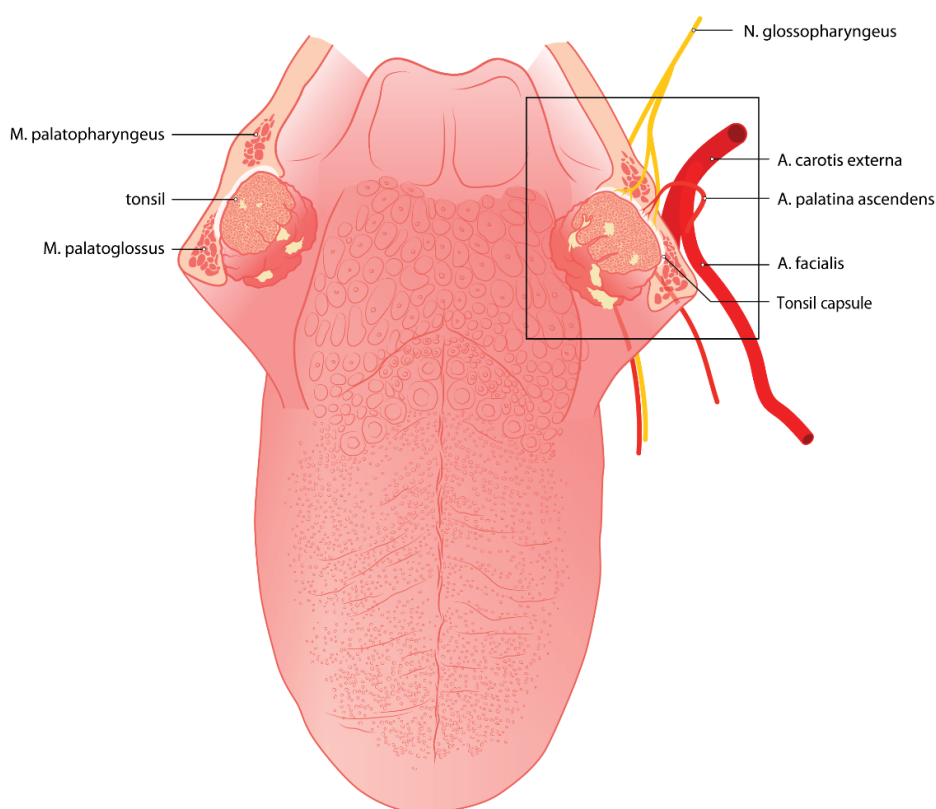


FIGURE 1. PALATINE TONSILS AND SURROUNDING ANATOMY. (NED TIJDSCHR GENEESKD. 2022;166:D6938)

Larger nerves and vessels lie within the capsule, supplying the tonsil, while smaller ones supply the crypts. Arterial supply comes mainly from branches of the external carotid artery: the tonsillar, lingual, ascending palatine, ascending pharyngeal, and descending

palatine arteries. Venous drainage starts in small veins that form two plexuses, and drains via paratonsillar veins into the facial and internal jugular veins. Sensory innervation is through the lesser palatine branches of the maxillary nerve (CN V2) and the glossopharyngeal nerve (CN IX).^{3,4}

The tonsillar crypts are lined with ciliated non-keratinized squamous epithelium which traps pathogens and facilitates lymphoid activation, including germinal centers and mantle zones, leading to effective T- and B-cell immune response.⁵

The function of the tonsil is the same throughout life, but there are differences between children and adults. In children, the tonsils are proportionally larger and play a key role in the developing immune system, contributing significantly to local innate immunity as children are more susceptible to respiratory infections. As the immune system matures, the tonsils shrink in adults, reflecting a reduced role in local immune defense with fewer B and T cells and lower bacterial load.⁶ However, they remain part of Waldeyer's ring, a larger local lymphoid structure, and continue contributing to the adaptive immune response, offering protection against respiratory and gastrointestinal infections. Consequently, tonsil removal in adults has minimal impact on the overall immune function, as the remaining lymphoid tissues can compensate. Any reduction in local immunity is generally minor and clinically insignificant.⁷

TONSIL-RELATED CONDITIONS AND THEIR IMPACT

Tonsillar disorders are prevalent and can significantly affect patients' quality of life. Common tonsil-related afflictions in adults include *acute and chronic tonsillitis*, *obstructive sleep apnea syndrome (OSAS)*, and *halitosis*.

Tonsillitis affects millions worldwide, leading to a substantial healthcare burden. In the United States, tonsillitis accounts for an estimated 40 million cases annually, representing over 5% of medical consultations. In France, around 9 million new cases are diagnosed each year. In Spain, 4 million annual cases constitute up to 15% of primary care visits.⁸ In Germany, over 120,000 patients are treated for acute tonsillitis each year, with chronic tonsil and soft palate conditions being the 7th most common health issue among women and the 6th among men.^{9,10} Although international data highlight the significant burden of tonsil-related conditions, the prevalence among adults in the Netherlands has historically been unclear.

Recurrent tonsil infections can progress to chronic tonsillitis with persistent symptoms such as sore throat, difficulty swallowing, and halitosis significantly impacting daily activities and overall well-being.¹²

OSAS is a common condition, which can be caused by large tonsils. The prevalence of OSAS is on the rise and is currently estimated at 6-17% in adults.¹³ Although paediatric OSAS is often due to enlarged tonsils and adenoids, adult OSAS is typically caused by other factors such as obesity (up to 70% of patients), older age, and lifestyle factors like alcohol consumption and smoking.^{14,15}

Halitosis has a wide range of causes, including tonsillar debris or stones (tonsillolithiasis). Halitosis affects around 24-41% of the population, but the true prevalence may be higher, as stigma often prevents individuals from seeking help and treatment.¹⁷

Tonsil-related conditions not only affect individual health but create significant socio-economic challenges as well.¹¹ A 2008 cost-of-illness study estimated adult pharyngitis-related costs in the United States around \$1.2 billion per year.¹⁸ These costs include direct healthcare-related costs, such as consultations and surgeries, and indirect costs from missed workdays and reduced productivity. Tonsil complaints are often chronic and recurrent which leads to high societal costs and strain on healthcare systems worldwide.

TREATMENT OF COMMON TONSIL DISEASES

Given the prevalence of tonsil-related conditions, appropriate management strategies are critical.

Non-surgical management

Non-surgical interventions are the first line of treatment for mild or early-stage tonsil diseases. Acute tonsillitis, typically viral and self-limiting, can be managed with rest and hydration. Antibiotics are reserved for bacterial infections or cases at high risk of potential complications such as endocarditis and rheumatoid arthritis.¹⁹ Symptom relief can be achieved with acetaminophen, Non-Steroidal Anti Inflammatory drugs (NSAIDs), and occasionally opioids.²⁰ Good oral hygiene and lifestyle rules, such as avoiding alcohol, smoking, and certain foods can help reduce recurrent tonsillitis and tonsil stones.^{22,23} Antibiotics are generally ineffective for chronic tonsillitis, in part because chronic tonsillitis leads to an impenetrable biofilm on the tonsil surface with high levels of antibiotic resistance.¹² Antiviral drugs such as acyclovir are not effective.¹⁰

In OSAS related to enlarged tonsils, lifestyle interventions including weight loss, avoiding alcohol and sedatives, and side sleeping can reduce symptoms. A continuous positive airway pressure device or a mandibular repositioning device may also be recommended.²¹

Surgical management

When conservative measures fail to provide sufficient relief, surgery may be necessary. Extracapsular dissection TE, which involves the complete removal of the tonsil and its capsule has been the traditional approach.

TE has a long history dating back to the Roman Empire, where the physician Cornelius Celsus (circa 40 AD) described removing the tonsils with his fingers. This method briefly resurfaced in the 20th century but was discontinued for safety reasons.²⁴ Over time, surgical techniques evolved, from knives in the Middle Ages to more modern methods like the guillotine, harmonic scalpel, electrocautery, radiofrequency ablation, coblation, microdebrider, and various lasers. Despite these developments, classic cold steel dissection TE under general anaesthesia remains the most performed method due to its established outcomes and familiarity.²⁵

Effectiveness of tonsillectomy

Classic dissection TE is an effective treatment for conditions such as recurrent tonsillitis and OSAS.^{26,27} The effectiveness of this procedure depends on patient characteristics and surgical indication.

For *recurrent tonsillitis*, previous studies demonstrate significant improvement in quality of life in adults. Douglas reported a reduction of the Health Impact of Throat Problems quality of life score from a median of 47 (out of 100) preoperatively to 4 six months post-operatively.²⁶ Senska saw a reduction in annual sore throat episodes from 10 before surgery to 2 at seven years post-operatively, along with decreases in doctor visits, analgesic use, antibiotic consumption, and work absences.²⁸ Alho found fewer throat infections and healthcare visits after TE compared to patients treated conservatively.²⁹

Despite its extirpative nature, TE does not always cure complaints attributed to recurrent tonsillitis. However, it generally improves quality of life by reducing the frequency and severity of these conditions.³⁰

In adult OSAS, a systematic review and meta-analysis by Camacho analyzed 17 studies involving 216 patients, demonstrating a significantly improved sleep parameters after TE with a 65.2% decrease in the Apnea-Hypopnea Index (AHI) from 40.5/hour to 14.1/

hour, improved oxygen saturation (from 77.7% to 85.5%), and a reduction in the Epworth Sleepiness Scale score from 11.6 to 6.1. TE showed an successful reduction of AHI in 85.2% of patients and resolution of OSAS in 57.4%. Treatment success was especially high in patients with hypertrophic tonsils and mild to moderate OSAS by reducing airway obstruction.¹⁶

Halitosis is considered a relative indication for TE when alternative causes have been excluded, symptoms persistent despite appropriate interventions and malodorous substrates are present within the tonsillar crypts. Although data are limited some studies show up to 100% resolution of symptoms after TE.³¹ TE is however often viewed as an excessively invasive, risky, and costly option when performed solely for halitosis.³¹

While studies suggest that TE can be effective for many tonsil-related afflictions, it is crucial to weigh the potential benefits against the risks and downsides of this intervention in adults.

Is classic dissection tonsillectomy in adults safe and patient-friendly?

TE is associated with considerable *postoperative pain, long recovery, and complications*.

Postoperative pain is more severe and prolonged in adults than in children, often requiring increased analgesic use.³² The pain can last up to two weeks and is caused by exposed muscle fibers and nerve endings, specifically the glossopharyngeal and vagus nerves, leading to inflammation and muscle spasms.^{33, 34} The pharyngeal constrictor muscles, essential in swallowing, become a major pain source, making swallowing uncomfortable and complicating recovery.³⁵

Postoperative hemorrhage is a serious and potentially life-threatening complication, with an incidence in adults around 5%–10%.^{36–38} However, when postoperative hemorrhages are actively assessed postoperatively in the context of clinical research, instead of relying solely on chart reviews, this rate increases to approximately 16%.³⁶ Bleeding can be categorized as primary (within the first 24 hours) and secondary (24 hours to 14 days post-surgery). Primary hemorrhages are generally due to insufficient hemostasis during surgery, while secondary hemorrhages are caused by the dissolution of blood clots, infection, or the exfoliation of necrotic tissue at the wound.³⁷ Bleeding usually stems from the external palatine vein or, less often, from arteries such as the tonsillar artery.¹ Mild bleeding can be managed conservatively, but more severe cases require surgical intervention and possibly blood transfusions. The mortality risk is 1 in 20,000 procedures in adults.^{38,39} An expected 30% of these deaths are due to injury to the internal carotid artery (ICA), the external carotid artery (ECA), or their branches.⁴⁰

Infection is the most common postoperative complication, increasing pain, secondary hemorrhage risks and delaying recovery. Patients can also develop pneumonia and urinary tract infections postoperatively.⁴¹

Other possible complications are dehydration from pain-induced difficulties with fluid intake, damage to adjacent anatomical structures, and velopharyngeal insufficiency.

These risks and the significant postoperative pain underscore the need for alternative procedures that reduce pain, recovery time, and complication rates while remaining effective in the treatment of tonsil-related conditions.

Are there feasible surgical alternatives for classic dissection tonsillectomy?

Less invasive alternatives to TE aim to reduce the size of the tonsils rather than removing them completely to reduce patient burden and improve recovery time.

Tonsillotomy (TO) constitutes the partial and intra-capsular removal of tonsil tissue. Even though TO is a century-old concept, it only regained clinically significant interest in the last decades.⁴² TO can be performed under either local or general anesthesia and is mostly used for treating pediatric obstructive sleep apnea syndrome, offering comparable efficacy to TE but fewer complications compared.⁴³ In Sweden, TO is now more commonly performed than TE for treating obstructive tonsil symptoms in children. Both procedures lead to high patient satisfaction, but TO is associated with fewer postoperative hemorrhages and a shorter recovery with less pain medication use.⁴⁴

There are a wide variety of surgical techniques available to perform a tonsillotomy including: microdebrider, coblation, CO₂-laser, electrocautery, cold steel, and bipolar scissors with each presenting unique advantages and disadvantages.

In *cold steel tonsillotomy* scalpels and scissors are used for the partial removal of the tonsil. Surgery is usually performed under general anesthesia. It offers precise control over tissue excision but carries a higher risk of intraoperative blood loss, postoperative hemorrhage when performed under local anesthesia compared to laser or coblation methods.⁴⁵

Coblation tonsillotomy uses low-temperature radiofrequency energy with saline to remove tonsil tissue, causing less thermal damage to surrounding tissues compared to electrosurgery. This results in reduced postoperative pain and faster recovery compared to electrosurgery. However, there is a higher risk of saline aspiration and an increased

incidence of postoperative hemorrhage when the procedure is performed under local anaesthesia.^{36,46}

Bipolar scissor diathermy tonsillotomy uses bipolar electrical energy through scissor-like instruments to cut and coagulate simultaneously. This technique offers precise tissue removal and effective hemostasis with limited intraoperative blood loss. There is a higher risk of postoperative hemorrhage, thermal damage, increased pain, and longer recovery times compared to other methods.⁴⁷

Microdebrider tonsillotomy utilizes a rotary cutting tool to shave down the tonsil tissue. This allows for precise tissue removal and is effective in preserving the underlying tonsillar capsule, reducing postoperative pain. The mechanical action of the microdebrider can lead to more significant tissue disruption⁴⁷ and microdebrider tonsillotomy is associated with increased perioperative blood loss and longer recovery times compared to other tonsillotomy methods.

CO₂-laser tonsillotomy evaporates tonsil tissue without direct tissue contact while simultaneously coagulating vessels, improving intraoperative hemostasis, reducing blood loss and improving the visual clarity of the surgical field. The CO₂-laser operates at a specific wavelength (10.6nm) with high water absorption characteristics, which helps with hemostasis and regulation of thermal diffusion, limiting unintentional damage to surrounding tissue.^{49,50} Current literature does not report any CO₂-laser specific complications, indicating a favorable safety profile. Previous research has also shown less intraoperative blood loss and fewer postoperative hemorrhages compared to cold dissection, diathermy, and coblation.⁵¹

While the various techniques described each offer unique advantages, CO₂-laser tonsillotomy stands out for its precise tissue ablation and minimal collateral damage. This thesis therefore evaluates whether CO₂-laser TO provides a safe and effective alternative to classic dissection TE in adults.

AIMS OF THIS THESIS

The studies in this thesis aim to evaluate the effectiveness, safety, and cost-effectiveness of CO₂-laser TO compared to TE in adults with tonsil-related conditions, addressing key gaps in current research.

To assess differences in surgical outcomes between TO and TE, **Chapter 2** presents a systematic review highlighting the need for high-quality studies due to inconsistent evidence and varying methodologies. **Chapter 3** builds on this with a prospective non-randomized cohort study comparing short-term outcomes, including postoperative pain, recovery time, and complication rates.

To ensure procedural consistency, **Chapter 4** outlines a detailed CO₂-laser TO protocol under local anesthesia to standardize practice and reduce clinical variability. Given the lack of national data on adult tonsil-related conditions, **Chapter 5** analyzes Dutch healthcare data to quantify the burden and support the need for less invasive treatments.

Chapter 6 reports the TOMTOM study's short-term outcomes, comparing recovery time, symptom resolution, and patient satisfaction between CO₂-laser TO and TE. **Chapter 7** extends this to long-term outcomes and cost-effectiveness, considering direct medical and societal costs.

Chapters 8 and 9 conclude with recommendations for clinical practice, surgical training, and future research.

Collectively, these studies aim to advance our understanding of CO₂-laser TO as a potentially safer, more cost-effective alternative to TE in adults.

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