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CO2-Lasertonsillotomy Under Local Anesthesia in Adults: a Step-by-Step Protocol

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Dear Editor,

We are pleased to submit our manuscript entitled: "CO2-Lasertonsillotomy Under Local Anesthesia in Adults: a Step-by-Step Protocol", for consideration as a video article in Journal of Visualized Experiments.

Tonsil-related complaints are very common in the adult population. Currently, tonsillectomy under general anesthesia is the most commonly performed surgical treatment in adults for such complaints. Unfortunately, tonsillectomy is an invasive treatment associated with a high complication rate and a long recovery time. Complications and a long recovery time are mostly related to removing the vascular and densely innervated capsule of the tonsils. Recently, CO2-lasertonsillotomy under local anesthesia has been demonstrated to be a viable alternative treatment for tonsil related disease with a significantly shorter and less painful recovery period. The milder side-effect profile of CO2-lasertonsillotomy is likely related to leaving the tonsil capsule intact. The aim of the current report is to present a concise protocol detailing the execution of CO2-lasertonsillotomy under local anesthesia.

We believe the Jove format is particularly well suited to provide ENT clinicians with a detailed visualized demonstration of the CO2-lasertonsillotomy.

This manuscript represents a valid work and neither this manuscript nor one with substantially similar content under my authorship has been published or is being considered for publication elsewhere. I agree to serve as the primary correspondent with the editorial office, to review the edited manuscript, and proof. I certify that all financial and material support for this research and work are clearly identified in the manuscript. I and the other authors have no relevant financial interests in this manuscript.

We appreciate your time and look forward to your response.

On behalf of all co-authors,

Sincerely,

Justin Wong Chung, M.D.

TITLE:

CO_2-Lasertonsillotomy under Local Anesthesia in Adults

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KEYWORDS:

Tonsillotomy, tonsil, surgery, laser, protocol, video, CO_2, local anesthesia, ENT

SUMMARY:

CO_2-lasertonsillotomy under local anesthesia is an interesting alternative treatment method for tonsillectomy under general anesthesia for tonsil-related complaints in adults. This report presents a step-by-step protocol detailing the execution of CO_2-lasertonsillotomy under local anesthesia.

ABSTRACT:

Tonsil-related complaints are very common among the adult population. Tonsillectomy under general anesthesia is currently the most performed surgical treatment in adults for such complaints. Unfortunately, tonsillectomy is an invasive treatment associated with a high complication rate and a long recovery time. Complications and a long recovery time are mostly related to removing the vascular and densely innervated capsule of the tonsils. Recently, CO_2-lasertonsillotomy under local anesthesia has been demonstrated to be a viable alternative treatment for tonsil-related disease with a significantly shorter and less painful recovery period. The milder side-effect profile of CO_2-lasertonsillotomy is likely related to leaving the tonsil capsule intact. The aim of the current report is to present a concise protocol detailing the execution of CO_2-lasertonsillotomy under local anesthesia. This intervention has been performed successfully in our hospital in more than 1000 patients and has been found to be safe and to be associated with a steep learning curve.

INTRODUCTION:

Recurrent tonsil disease is a common health problem resulting in frequent visits to outpatient clinics, antimicrobial treatments, and missed work days[1]. Tonsillectomy[2] is currently the most used surgical intervention for tonsil-related complaints in adults. During a tonsillectomy, the patient is brought under general anesthesia and the entire tonsil, including the tonsil capsule, is removed followed by diathermy coagulation of any bleeding sites. This intervention is rather invasive and associated with significant post-operative morbidity and a long, typically painful, recovery period[3, 4]. An alternative to tonsillectomy is tonsillotomy, which is the partial intra-capsular removal of the tonsil tissue.

Both tonsillectomy and tonsillotomy have been performed for millennia [5, 6]. The first descriptions of subtotal tonsil removal date back to 1 BC[6]. Since that time many techniques for tonsil removal have been developed including the use of scalpels, microdebriders[7], coblators[8], electrosurgical scissors[9], diode-lasers[10], radiofrequency probes[11] and CO_2-lasers[12].

CO_2-lasertonsillotomy under local anesthesia (CO2LT) for the treatment of tonsil-related complaints is a fairly novel surgical treatment, which is gaining popularity as an alternative for the classic tonsillectomy. Recent studies have shown a shorter and less painful recovery period, but similar overall patient-satisfaction with CO2LT treatment when compared to conventional tonsillectomy[12, 13]. During a CO2LT the tonsil is locally anesthetized and only the lobules of lymphatic tonsillar tissue are removed. The tonsillar capsule, through which blood vessels, nerves and lymphatic vessels pass, is left intact. Leaving the tonsillar-capsule intact likely leads to a reduced rate of post-operative bleeding, reduced post-operative pain, and a shorter recovery time[14].

A potential problem with leaving the tonsillar capsule intact can be the incomplete resolution of the tonsil-related complaints, resulting in the need for a secondary CO2LT in a subset of patients[12]. Furthermore, to be eligible for CO2LT treatment patients must be able to remain calm during treatment and their gag reflex intensity should not limit treatment possibilities. The gag reflex is a physiological reflex to protect the airway[15], which can only be partly blunted by local anesthesia in the mouth and pharynx; a particularly strong gag reflex can compromise the safe performance of a CO2LT. To assess the severity of the reflex the Gagging Severity Index (GSI) can be used[15]. The GSI is an index ranging from 1 (very mild) to 5 (very severe) [**Table 1**] and was originally developed in dentistry to classify the intensity of the gagging reflex and its consequences for dental treatments. In any patient with a GSI grade 3 or more the gagging reflex should first be reduced to increase the odds that the CO2LT procedure will be successful. We advise patients to try to fade out their gag-reflex by “brushing” their tongue-base and tonsils each time they brush their teeth. We have found this exercise to be capable of reducing the gag reflex intensity in most patients by 1–2 GSI points.

PROTOCOL:

1. Patient selection

1.1. Consider inclusion of patients with the following tonsil-related diseases: recurrent tonsillitis; dysphagia caused by large tonsils; tonsil stones; obstructive sleep apnea related to tonsils.

1.2. Include only adult patients.

1.3. Check for allergies, specifically to local anesthetics.

1.4. Assess the gag-reflex intensity using the GSI (**Table 1**). For adequate CO2LT treatment, full visualization of the tonsils is required and patients need to be able to hold their breath for at least 15 s at a time.

1.5. In patients with a GSI > 2 consider the following exercise to decrease the gag-reflex intensity.

1.5.1. Inform the patient that the gag-reflex can be (partially) faded-out by training.

1.5.2. Explain to the patient that the exercise will be uncomfortable in the first few days to weeks.

1.5.3. Advise the patient to use their toothbrush to gently touch / brush their tongue base and tonsils each time they brush their teeth (preferably twice a day). Instruct the patient to increase pressure when performing this procedure each sequential day.

1.6. Exclude the following patients: with Friedman grade IV (kissing) tonsils; with undertreated coagulation disorders; using any form of anticoagulants; with an active tonsil infection / peritonsillar abscess; women who are pregnant; those who are uncooperative during tonsil examination.

2. Informed consent and pre-operative instruction visit

2.1. Obtain written informed consent including the following.

2.1.1. Explain the intervention to the patient as follows: "The tonsil(s) will be partially evaporated using a laser beam. Local anesthesia will be used to numb the tissue and therefore you will be fully awake and mentally present during treatment. No pain is expected during treatment and low to moderate pain may occur in the first days after treatment. Treatment will take approximately 10–15 min per tonsil. If no complications occur, admission to the floor after treatment is not necessary and you will be able to leave the hospital in 30 min to an hour after treatment, accompanied by a friend or relative that is able to drive you."

2.1.2. Explain alternative treatment options (where applicable: expectant management, conventional tonsillectomy or antibiotics).

2.1.3. Explain possible complications of the CO2LT including: per- and post-operative bleeding, infection, incomplete resolution of tonsil disease; need for a second tonsillotomy or a tonsillectomy, pain, allergic reaction to anesthetic, temporary change of taste, (temporary)

damage to surrounding structures.

2.2. Instruct the patient not to eat any heavy meals on the day of treatment.

2.3. Instruct the patient to take 1000 mg acetaminophen (paracetamol) 30 min before treatment if acetaminophen is not contraindicated in that specific patient (including, but not limited to active liver disease and liver failure).

2.4. Ask patients with a troublesome gag-reflex during examination to reduce the gag-reflex by rubbing their tongue base and tonsils with their toothbrush at least twice a day for 1 min, preferably for at least 2 weeks.

3. Preparation of patient and equipment

3.1. Attach the laser pen to the CO_2-laser machine.

3.2. Make sure that the correct settings are chosen (**Figure 1**) such as (i) continuous laser beam, (ii) 15–30 W intensity depending on the size of the tonsil; generally, start at 18 W and increase the power up to 30 W depending on the size of the tonsils and patient‘s cooperation . (iii) shape-size of 2–4 mm depending on the size of the (remainder of the) tonsil, (iv) shape: round.

3.3. Make sure that the surgeon, the surgical technologist, and the patient are wearing laser safety glasses.

3.4. Make sure that the surgeon and the surgical technologist are wearing appropriate protective surgical masks.

3.5. Confirm that the headlight for the surgeon is working.

3.6. Confirm that a pulse oximeter for patient monitoring is present.

3.7. Confirm that wooden tongue depressors are within reach.

CAUTION: Do not use metal depressors, since they can reflect the laser beam.

4. Time-out procedure

4.1. Ask the patient for their name and date of birth.

4.2. Ask the patient for the intervention that will take place.

4.3. Ask the patient for the side of treatment.

4.4. Ask the patient for any allergies, specifically for local anesthetics and medications.

4.5. Check with the surgical technologist if all equipment is present.

4.6. Check if the laser-indication light of the operating room is switched on and all windows are covered for laser safety.

5. Patient instructions before surgery

5.1. Ask the patient to inhale deeply, followed by breathing out slowly during treatment.

5.2. Explain to the patient that he/she is in control and can signal at any time, which will lead to a pause of the laser-treatment.

5.3. Instruct the patient to use his/her hand to signal if they wish to pause treatment by tapping the surgeon's leg.

5.4. Instruct the patient not to swallow any liquids during treatment to prevent aspiration and laryngospasms. Provide a kidney basin to the patient to spit any liquids into when necessary.

5.5. Reassure the patient not to panic if they experience a feeling as if their airway is blocked, as this is due to local anesthesia of the pharynx region. Remind the patient again that the treatment can be paused at any moment.

6. **Positioning the patient and inspection of the tonsils**

6.1. Place the pulse oximeter on the patient's index finger and confirm that it is functioning correctly.

6.2. Position the patient in an upright position using the chair / table controls.

6.3. Set the height of the chair / table so that the surgeon can stand straight comfortably while performing the laser treatment.

6.4. Ask the patient to make any adjustments to the seating to ensure comfortable and safe positioning.

6.5. Inspect both tonsils and exclude active inflammation.

6.6. Assess the gag-reflex using the GSI and judge the feasibility of the laser treatment. For adequate CO2LT treatment, the surgeon should be able to fully visualize the tonsils and patients need to be able to hold their breath for at least 15 s.

7. Sedation of the tonsil

7.1. Tell the patient that the tonsils will be anesthetized one at a time.

7.2. In case of a significant gag-reflex (GSI grade 2–3) use xylocaine-spray or superficial anesthesia of the tongue-base and pharynx to reduce the gag-reflex.

7.3. Take an ampule with local anesthetic and inject ~0.2 mL slowly into the upper pole, ~0.2 mL into the mid-pole and 0.2 mL into the lower-pole of the tonsil.

NOTE: Optionally, the tonsil-pillars can be infiltrated as well. This is recommended when the tonsils are hidden behind the pillars or to decrease the gag-reflex.

7.4. Instruct the patient not to swallow any local anesthetic, but to spit it out.

7.5. Reassure the patient that any feeling of throat tightness is due to the anesthetic; not due to any actual obstruction.

8. Laser-treatment of the tonsil

8.1. Ask the patient to breathe in deeply and exhale slowly.

8.2. Have the surgical technologist hold the smoke suction close to the opening of the mouth, without blocking the surgeon's view.

8.3. Use two wooden tongue blades to depress the tongue / tongue-base and expose the tonsil.

8.4. During the patient's exhalation, laser the lymphatic tissue of the lobules in a sweeping motion.

8.5. Stop when the patient taps your (the surgeon's) leg.

8.6. Let the patient catch his/her breath again and repeat steps 8.1–8.4 until complete cryptolysis is accomplished.

8.7. If necessary, inject extra local anesthetic (with or without epinephrine).

9. Tips for laser treatment

9.1. In case of peroperative hemorrhage: laser the spot that is bleeding "out of focus". This will lead to burning of the lymphatic tissue with crust formation with a similar effect as coagulation (opposed to evaporation when using the laser 'in focus'). Alternatively, use a (bipolar) coagulation device to stop the bleeding.

9.2. Use the wooden tongue blades to press against the anterior tonsillar pillar to expose the tonsil further.

9.3. Use the wooden tongue blades to press against the upper part of the tonsil pillars to expose the upper lobule of the tonsil.

9.4. Use the wooden tongue blades to scoop up the lower tonsil lobule and expose it for laser treatment (one can leave them scooped up on the tongue blades).

10. Instructions after treatment

10.1. Give the patient a popsicle for a minimum of 30 min of postoperative observation.

10.2. Instruct the patient not to drink or eat anything else for 2 h until the local anesthetic has worn off to prevent aspiration.

10.3. Instruct the patient not to drink / eat hot (temperature) or spicy drinks / food or food with hard crusts for a week to prevent postoperative bleeding.

10.4. Tell the patient to take pain medication only if necessary.

NOTE: We advise a maximum of 1000 mg acetaminophen (paracetamol) 4 times a day, if necessary.

10.5. Tell the patient to refrain from strenuous physical exercise for a week.

10.6. Advise the patient to go to the nearest emergency department in case a postoperative bleeding occurs. Advise the patient to contact the ENT department in case of a postoperative infection (e.g., fever).

REPRESENTATIVE RESULTS:

In a previously published prospective study in 107 patients with one year follow-up, postoperative questionnaires were used to assess recovery rate and recurrence of tonsil-related symptoms for CO2LT compared to conventional tonsillectomy[12]. Forty-six patients underwent conventional tonsillectomy under general anesthesia and 61 patients underwent CO2LT. In total, 72.5% of patients in the CO2LT group were cured from their tonsil-related symptoms. Three patients (7.5%) in the CO2LT group required revision surgery for recurring tonsil complaints. In the tonsillectomy group, 97.2% of patients were cured after initial treatment. The overall satisfaction rate was similar in both treatment groups, but the mean pain intensity scores two weeks post-operatively were 5.4 (out of 10, range 0–9) after tonsillotomy and 7.7 (out of 10, range 2–10) after tonsillectomy leading to longer (9.9 vs. 5.4) use and use of stronger pain medication (NSAIDs / opioids versus acetaminophen) after tonsillectomy. Days to full recovery and number of post-operative bleeding events were both significantly higher in the tonsillectomy group (**Figure 2**).

FIGURE AND TABLE LEGENDS:

Figure 1: Photo of laser settings. Standard laser settings for CO2LT on the laser system used.

Figure 2: Patient reported recovery after tonsillotomy and tonsillectomy. Cumulative percentage of patients that reported complete recovery postoperatively after tonsillotomy (TO) and tonsillectomy (TE). Data were previously published by Lourijssen et al.[12].

Table 1: Gagging Severity Index (GSI) score[15].

DISCUSSION:

This paper describes the steps to perform a CO2LT. To our knowledge, this is the first article to describe this intervention in such detail. Outpatient CO2LT under local anesthesia is a novel surgical method and therefore the presented procedural details have mostly been developed through hands-on experience of the authors.

As for any surgical intervention, pre-operative patient selection is important. For CO2LT, a relatively calm and cooperative patient without a procedure-restricting gag-reflex is desirable. Therefore, an adequate assessment of limitations due to patient anxiety pertaining to the procedure and gag-reflex are of great importance to reach consistent treatment effects. Furthermore, we advise not to perform CO2LT on patients with grade IV (Friedman grading), or "kissing-tonsils" because of the risks of damaging surrounding tissues with the laser-beam.

In our experience, leaving the tonsil capsule intact and limiting the tissue damage reduces post-operative pain, recovery time and post-operative morbidity compared to tonsillectomy under general anesthesia. This is in agreement with current literature[16–26]. Despite the potential incomplete resolution of tonsil disease with CO2LT, many patients prefer CO2LT over tonsillectomy when informed of their options. This preference has been consistently reported prospectively (pre-surgery) and retrospectively (at follow-up)[12]. We therefore believe that CO2LT fills a gap in treatment options for tonsil-related disease, both from the doctors' and the patients' perspective. Current ongoing studies should provide further insight into the value of CO2LT in adults with tonsil diseases[13].

There is a wide variety of techniques and devices available to perform a tonsillotomy, each with its own potential pros and cons. Utilized surgical devices besides the CO_2-laser include microdebriders, coblators, surgical scissors, radiofrequency ablation probes, interstitial thermal therapy instruments and diode lasers. There is no conclusive evidence favoring any one instrument over another for tonsillotomy in adults[27]. Microdebriders, coblators and CO_2-lasers are among the most frequently used instruments for tonsillotomy[28]. Reports on effectiveness, pain and postoperative complications vary, but current evidence suggests equal efficacy of tonsillotomy compared to tonsillectomy with less postoperative pain and complications[27, 28], independent of the method of tonsillotomy.

Even though tonsil-surgery under local anesthesia has been described since decades, it is not performed often in current practice[16, 29–31]. Many otolaryngologists are uncomfortable with the

idea of tonsil surgery under local anesthesia. This may partly be due to a lack of experience with this specific form of tonsil surgery as well as due to concerns over the airway and bleeding control[30].

CO2LT has some clear logistical advantages. First, using only local anesthetics obviates the need for an anesthesia team. Second, the operation can be performed in the outpatient setting and there is no need for an operation room. Third, the surgical instruments used with CO2LT are non-disposable and only the laser pen needs to be sterilized after use. Sterilization of the laser pen is a simple procedure for any central sterile services department. These factors all lead to cost-reduction. On the other hand, the use of a laser requires a specialized intervention room meeting the local laser safety standards.

We currently exclude patients with a history of peritonsillar abscess because of the intrinsic risk in those patients of recurrent peritonsillar abscess (14%)[32]. The risk of recurrence is zero in patients after tonsillectomy[33]. In tonsillotomy, residual tissue may lead to a recurrence of an abscess. We also advise to exclude patients on anticoagulants or with bleeding disorders from treatment with CO2LT. Even though our experience is that bleeding sites can easily be managed with the CO_2-laser, or if necessary, with bipolar coagulation. The fact that the patient is conscious and not intubated might complicate per-operative treatment of more profound bleeding due to decreased coagulation. If necessary, the patient can be brought under full anesthesia and the bleeding site can be stopped with diathermy or ligation, similar to postoperative bleeding after tonsillectomy. In our >1000 patient experience, such an event has never occurred. We estimate the need to use bipolar coagulation under local anesthesia to be around 2% of cases.

Furthermore, as of yet we have never had to stop a CO2LT case early due to an uncooperative patient. Incidentally a strong gag-reflex has led to suboptimal laser-treatment of the lower part of the tonsil. In those cases, sending the patient home with our gag-reflex training scheme led to successful treatment of the remaining tonsil tissue during a subsequent CO2LT procedure. It is important to note that these numbers and procedural characteristics are based on personal experience of the authors at a single center and should be evaluated in further studies.

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REFERENCES:

1. Koskenkorva, T., Koivunen, P., Alho, O.-P. Predictive Factors for Medical Consultation for Sore Throat in Adults with Recurrent Pharyngotonsillitis. *International Journal of Otolaryngology*. **2016**, doi: 10.1155/2016/6095689 (2016).
2. Cullen, K.A., Hall, M.J., Golosinskiy, A. Ambulatory surgery in the United States, 2006. *National Health Statistics Reports*. (11), 1–25 (2009).
3. Bhattacharyya, N., Kepnes, L.J. Revisits and postoperative hemorrhage after adult

tonsillectomy. *The Laryngoscope*. **124** (7), 1554–1556, doi: 10.1002/lary.24541 (2014).
4. Salonen, A., Kokki, H., Nuutinen, J. Recovery After Tonsillectomy in Adults: A Three-Week Follow-up Study. *The Laryngoscope*. **112** (1), 94–98, doi: 10.1097/00005537-200201000-00017 (2002).
5. Younis, R.T., Lazar, R.H. History and current practice of tonsillectomy. *The Laryngoscope*. **112** (8 Pt 2 Suppl 100), 3–5, doi: 10.1002/lary.5541121403 (2002).
6. Koempel, J.A., Solares, C.A., Koltai, P.J. The evolution of tonsil surgery and rethinking the surgical approach to obstructive sleep-disordered breathing in children. *The Journal of Laryngology and Otology*. **120** (12), 993–1000, doi: 10.1017/S0022215106002544 (2006).
7. Koltai, P.J., Solares, C.A., Mascha, E.J., Xu, M. Intracapsular partial tonsillectomy for tonsillar hypertrophy in children. *The Laryngoscope*. **112** (8 Pt 2 Suppl 100), 17–19, doi: 10.1002/lary.5541121407 (2002).
8. Arya, A., Donne, A.J., Nigam, A. Double-blind randomized controlled study of coblation tonsillotomy versus coblation tonsillectomy on postoperative pain. *Clinical Otolaryngology and Allied Sciences*. **28** (6), 503–506 (2003).
9. Isaacson, G., Szeremeta, W. Pediatric tonsillectomy with bipolar electrosurgical scissors. *American Journal of Otolaryngology*. **19** (5), 291–295 (1998).
10. D'Eredità, R., Marsh, R.R. Contact diode laser tonsillectomy in children. *Otolaryngology--Head and Neck Surgery: Official Journal of American Academy of Otolaryngology-Head and Neck Surgery*. **131** (5), 732–735, doi: 10.1016/j.otohns.2004.04.031 (2004).
11. Hegazy, H.M., Albirmawy, O.A., Kaka, A.H., Behiry, A.S. Pilot comparison between potassium titanyl phosphate laser and bipolar radiofrequency in paediatric tonsillectomy. *The Journal of Laryngology and Otology*. **122** (4), 369–373, doi: 10.1017/S0022215107008328 (2008).
12. Lourijsen, E.S., Wong Chung, J.E.R.E., Koopman, J.P., Blom, H.M. Post-operative morbidity and 1-year outcomes in CO2-laser tonsillotomy versus dissection tonsillectomy. *Acta Oto-Laryngologica*. **136** (10), 983–990, doi: 10.1080/00016489.2016.1183040 (2016).
13. Wong Chung, J.E.R.E. Trial info: CO2-Lasertonsillotomy versus tonsillectomy in adults; a randomized multicentre study. at <http://www.trialregister.nl/Trialreg/admin/rctview.asp?TC=7044>.
14. Hultcrantz, E., Ericsson, E. Pediatric tonsillotomy with the radiofrequency technique: less morbidity and pain. *The Laryngoscope*. **114** (5), 871–877, doi: 10.1097/00005537-200405000-00016 (2004).
15. Dickinson, C.M., Fiske, J. A review of gagging problems in dentistry: I. Aetiology and classification. *Dental Update*. **32** (1), 26–28, 31–32, doi: 10.12968/denu.2005.32.1.26 (2005).
16. Krespi, Y.P., Ling, E.H. Laser-assisted serial tonsillectomy. *The Journal of otolaryngology*. **23** (5), 325–327 (1994).
17. Unkel, C., Lehnerdt, G., Schmitz, K.J., Jahnke, K. Laser-tonsillotomy for treatment of obstructive tonsillar hyperplasia in early childhood: a retrospective review. *International Journal of Pediatric Otorhinolaryngology*. **69** (12), 1615–1620, doi: 10.1016/j.ijporl.2005.08.017 (2005).
18. Papaspyrou, G., Linxweiler, M., Knöbber, D., Schick, B., Al Kadah, B. Laser CO2 tonsillotomy versus argon plasma coagulation (APC) tonsillotomy: A retrospective study with 10-year follow-up. *International Journal of Pediatric Otorhinolaryngology*. **92**, 56–60, doi: 10.1016/j.ijporl.2016.11.007 (2017).
19. Linder, A., Markström, A., Hultcrantz, E. Using the carbon dioxide laser for tonsillotomy in

children. *International Journal of Pediatric Otorhinolaryngology*. **50** (1), 31–36 (1999).
20. Baharudin, A., Shahid, H., Rhendra, M.Z. Laser tonsillotomy in children with tonsillar hyperplasia. *The Medical journal of Malaysia*. **61** (3), 377–379 (2006).
21. Linder, A., Markström, A., Hultcrantz, E. Using the carbon dioxide laser for tonsillotomy in children. *International Journal of Pediatric Otorhinolaryngology*. **50** (1), 31–36, doi: 10.1016/S0165-5876(99)00197-4 (1999).
22. Magdy, E.A., Elwany, S., El-Daly, A.S., Abdel-Hadi, M., Morshedy, M.A. *Coblation tonsillectomy: a prospective, double-blind, randomised, clinical and histopathological comparison with dissection–ligation, monopolar electrocautery and laser tonsillectomies*. at </core/journals/journal-of-laryngology-and-otology/article/coblation-tonsillectomy-a-prospective-double-blind-randomised-clinical-and-histopathological-comparison-with-dissectionligation-monopolar-electrocautery-and-laser-tonsillectomies/EFB5CAAD6E4351DE28747E975D5F2226/core-reader>. (2008).
23. Ove Densert, C.W., Hilmi Desai, Alf Eliasson, Lone Frederiksen, Dan Andersson, Jan Olaison Tonsillotomy in Children with Tonsillar Hypertrophy. *Acta Oto-Laryngologica*. **121** (7), 854–858, doi: 10.1080/00016480152602339 (2001).
24. Krespi, Y.P., Kizhner, V. Laser tonsil cryptolysis: In-office 500 cases review. *American Journal of Otolaryngology*. **34** (5), 420–424, doi: 10.1016/j.amjoto.2013.03.006 (2013).
25. Stelter, K., Chaux, R. de la, Patscheider, M., Olzowy, B. Double-blind, randomised, controlled study of post-operative pain in children undergoing radiofrequency tonsillotomy versus laser tonsillotomy. *The Journal of Laryngology & Otology*. **124** (8), 880–885, doi: 10.1017/S0022215110000605 (2010).
26. Hultcrantz, E., Linder, A., Markström, A. Tonsillectomy or tonsillotomy?--A randomized study comparing postoperative pain and long-term effects. *International Journal of Pediatric Otorhinolaryngology*. **51** (3), 171–176 (1999).
27. Wong Chung, J.E.R.E., van Benthem, P.P.G., Blom, H.M. Tonsillotomy versus tonsillectomy in adults suffering from tonsil-related afflictions: a systematic review. *Acta Oto-Laryngologica*. **138** (5), 492–501, doi: 10.1080/00016489.2017.1412500 (2018).
28. Windfuhr, J.P., Savva, K., Dahm, J.D., Werner, J.A. Tonsillotomy: facts and fiction. *European archives of oto-rhino-laryngology: official journal of the European Federation of Oto-Rhino-Laryngological Societies (EUFOS): affiliated with the German Society for Oto-Rhino-Laryngology - Head and Neck Surgery*. **272** (4), 949–969, doi: 10.1007/s00405-014-3010-x (2015).
29. Schoem, S.R., Watkins, G.L., Kuhn, J.J., Alburger, J.F., Kim, K.Z., Thompson, D.H. Control of Early Postoperative Pain With Bupivacaine in Adult Local Tonsillectomy. *Archives of Otolaryngology–Head & Neck Surgery*. **119** (3), 292–293, doi: 10.1001/archotol.1993.01880150040007 (1993).
30. Bredenkamp, J.K., Abemayor, E., Wackym, P.A., Ward, P.H. Tonsillectomy under local anesthesia: A safe and effective alternative. *American Journal of Otolaryngology*. **11** (1), 18–22, doi: 10.1016/0196-0709(90)90165-R (1990).
31. Pekkarinen, H., Kärjä, J. Results of long-term ECG monitoring in patients submitting to tonsillectomy under local anaesthesia. *The Journal of Laryngology and Otology*. **96** (8), 725–730 (1982).
32. Chung, J.H., Lee, Y.C., Shin, S.Y., Eun, Y.G. Risk factors for recurrence of peritonsillar abscess. *The Journal of Laryngology and Otology*. **128** (12), 1084–1088, doi: 10.1017/S002221511400259X

(2014).
33. Kronenberg, J., Wolf, M., Leventon, G. Peritonsillar abscess: recurrence rate and the indication for tonsillectomy. *American Journal of Otolaryngology*. **8** (2), 82–84 (1987).

Figure 1

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Figure 2 PDF

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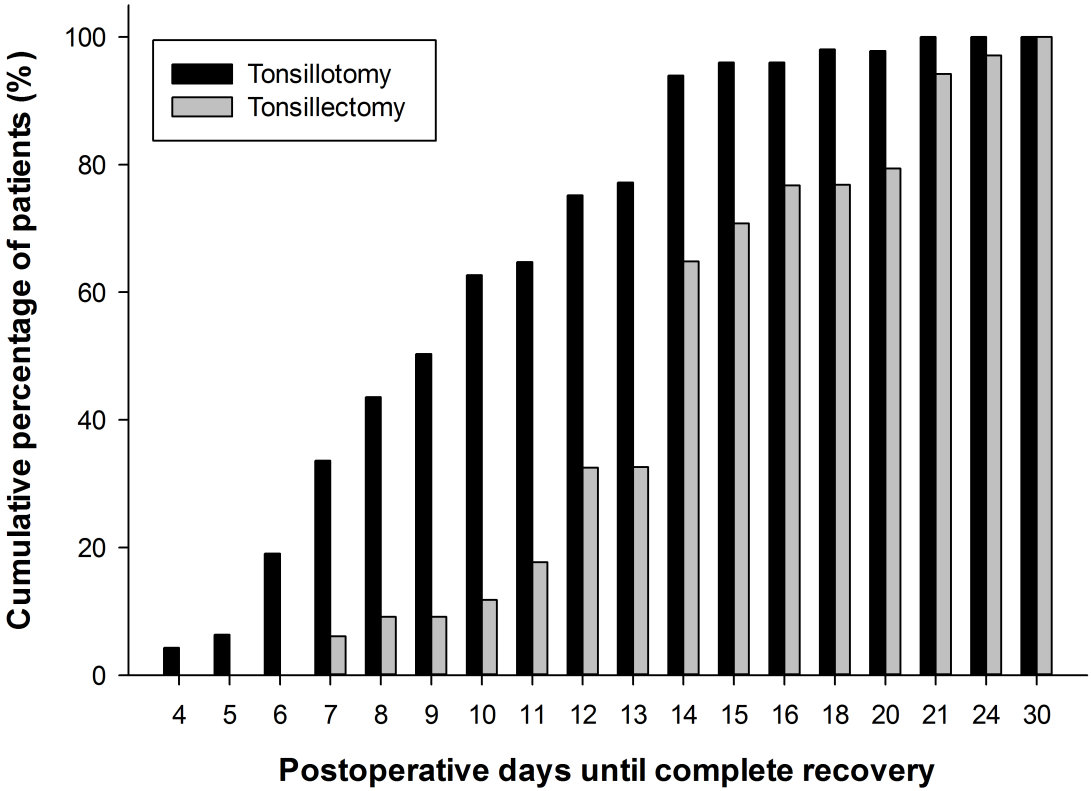

Table

Dickinson and Fiske Gagging Severity Index grades
Grade I
Grade 2
Grade 3
Grade 4
Grade 5

Definition and characteristics of grade of reflex
Very mild, occasional and controlled by the patient.
Moderate, control is required by the patient with reassurance from the dental team.
Moderate, consistent and limits treatment options.
Severe and treatment is impossible.
Very severe, affecting patient behavior and dental attendance and making treatment impossible.

Name of Material/ Equipment	Company	Catalog Number	Comments/Description
Carpule syringe and local anesthetic (eg xylocaïne:adrenaline 1:80.000)	n/a	n/a	n/a
CO_2 Laser system	Lumenis	AcuPulse DUO CO2 laser	F125 CO_2 Laser System
Coagulation device	Erbe	Erbe ICC 80 Surgical Generator With Footswitch	n/a
Laser safety goggles	Lumenis	Laservision goggles AX0000068	n/a
Operating chair	n/a	n/a	With possibilities for the pa
Operating room which meets the local laser-safety standards	n/a	n/a	n/a
Suction device	TBH	TBH LN 100 or 2000	Air suction and filtration de
Surgical masks	3M	3M 7502 mask with 2138 P3 filters	n/a
wooden tongue depressor	n/a	n/a	Do not use metal tongue de

ıtient to sit upright (eg opthalmic chair or dental chair)

:vice

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Author(s):	Justin E.R.E. Wong Chung, Noud van Helmond, Peter Paul G. van Benthem, Henk M Blom

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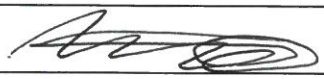
Signature:	
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Dear Dr. D. Souza,

We thank you and the anonymous reviewer for the constructive comments, which helped us to improve the manuscript. Below, we address all comments point-by-point discussing the subsequent modifications.

On behalf of all co-authors,

Justin Wong Chung

Editorial Comments:

- We corrected the spelling and grammar where applicable
- We changed the protocol numbering
- We highlighted the most important steps of the protocol
- The discussion should cover the subjects mentioned. We also tried to keep the size of the discussion limited as suggested.
- We changed the figures and removed AcuPulse an SurgiTouch

Reviewer 1:

Sub-total tonsil surgery or Tonsillotomy is not new. There is a massive volume of literature on the procedure, including several meta-analyses which are omitted from the reference list. The introduction should briefly cover the evolution of subtotal tonsil surgery (which was performed even before full tonsillectomy 100 years ago), through to the Swedish experience, Koltai, Carney, Cervin and others work.

Agreed.We have rewritten the Introduction section to include the evolution subtotal tonsil surgery. In the Disccusion section we now reference several additional meta-analyses.

The discussion needs to cover Coblation and microdebrider subtotal tonsil surgery and address the positives of laser (no disposable costs) and negatives (laser safety, poorer haemostasis) and cover relative pain experiences.

We now discuss different alternative surgical techniques for subtotal tonsil surgery in the Discussion section. We also discuss the mentioned pros and cons of CO2LT.

needs improving for english.

We have improved spelling and grammar throughout the manuscript.

Reviewer 2:

It is an interesting method, i would like also to learn the percentage of patients who finally cooperate with the topical aneasthesia irrespectively their gag reflex index

We have not cancelled any cases due to inability to perform the procedure in a patient. In incidental cases, the procedural result has been suboptimal, mainly due to limitations in exposure of the lower part of the tonsil. If these patients experienced remission of their tonsil related symptoms, we offered a second CO2LT and advised patients to decrease their gag-reflex with our training schedule prior to the procedure.

Reviewer 3:

Did you regularly use 30 Watts to perform a tonsillotomy? You are stating: 15-30 watt depending on the size of the tonsil. Does this mean for example that for all the Friedman tonsil 4 cases you used 30 W? What was your protocol?

We generally startat a power of 18 Watt, which has been added to the protocol. The power can be increased up to 30 Watt when encountering large tonsils, provided that the surgeon has adequate vision and the patient is cooperative

The bleeding rates of a tonsillotomy are generally lower than that of a tonsillectomy. Maybe due to competence, maybe due to luck, you mentioned that in the 1000 laser tonsillectomies that you performed no conversion to general anesthesia was necessary. In how many cases of these thousand did you have to use bipolar coagulation? 50, 200, 800? I am asking the authors since the use of bipolar coagulation is in many cases, even in the most experienced hands of laser experts, necessary, but the use of bipolar coagulation is associated with postoperative pain.

We do not have exact number of cases in which bipolar coagulation was needed for these >1000 cases. We reviewed the 100 most recent CO2LT we performed and found that bipolar electrocoagulation was needed twice. We added this information to the Discussion section.

The following articles should be cited:

1) The review of Windfuhr et al.Tonsillotomy: facts and fiction. Eur Arch Otorhinolaryngol. 2015 Apr;272(4):949-969.
2) The articles about the use of CO2 laser in tonsillotomy
a) The article of Unkel et al.Laser-tonsillotomy for treatment of obstructive tonsillar hyperplasia in early childhood: a retrospective review.Int J Pediatr Otorhinolaryngol. 2005 Dec;69(12):1615-20.
b) The article of Papaspyrou et al.Laser CO2 tonsillotomy versus argon plasma coagulation (APC) tonsillotomy: A retrospective study with 10-year follow-up.Int J Pediatr Otorhinolaryngol. 2017 Jan;92:56-60.

These articles are now cited in the section that their content pertains to.