Eur Arch Otorhinolaryngol (2013) 270:2985–2996
DOI 10.1007/s00405-013-2577-y

EDITORIAL

Tonsillotomy: it's time to clarify the facts

Jochen P. Windfuhr · Jochen A. Werner

Published online: 22 August 2013

Introduction

Finger nails, wires, specialized knives, slings and guillotines in the 19th and 20th century were used for subtotal tonsillectomy to reduce the risk of serious bleeding complications associated with complete removal of tonsillar tissues. Therefore, success of tonsil procedures at that time was widely based on revision surgery to cure patients suffering from diseases associated with tonsillitis. Complete, i.e., extracapsular, tonsillectomy (TE) was conceived in the first decade of the 20th century but became widespread only with safer anesthesiological techniques, particularly orotracheal intubation and introduction of halothan in the 1950s [1, 2].

In 1990, Rosenfeld registered a dramatic rise in obstructive sleep apnea (OSA) as a significant indication for TE. He assumed that this phenomenon is due to the increasing awareness of the prevalence and seriousness of adenotonsillar hypertrophy as a cause of sleep apnea, particularly in children [3]. His statement and findings were confirmed recently by Parker and Walner [4]. OSA belongs to the category of sleep-disordered breathing (SDB), characterized by abnormal respiratory patterns or the inadequate ventilation during sleep in terms of snoring, mouth breathing, or interrupted breathing. The patients may become symptomatic with excessive sleepiness, inattention, poor concentration, or hyperactivity during daytime. According to the latest statement of the American Academy of Otolaryngology-Head and Neck Surgery, TE still plays a major role to resolve SDB related to tonsillar hypertrophy in children [5]. Morbidity following TE is widely determined by pain and significant limitations in activity and diet. Return to normal diet and activity, intake of analgesics and type of consumed analgesics are therefore common endpoints of studies evaluating the benefit of newer surgical TE instruments. Complications like hemorrhage and dehydration eventually occur with the potential of a devastating outcome [6, 7]. While the best method to avoid surgical complications is *not* to operate, this is not an option for upper airway obstruction caused by tonsillar hypertrophy. TE, however, is acknowledged to control SDB in only 60–70 % of children with significant tonsillar hypertrophy, emphasizing the multifactorial background of this disease [5].

In the light of the limited success rate and the potential complications of TE alternative surgical procedures such as a Bochon loop have been suggested in 1993 [8], cited after [2]. In 1994, Krespi and Ling [9] recommended the CO_2-LASER for "serial tonsillectomy" to treat recurrent infection, sore throat, and halitosis in adults. In children, a considerably reduced morbidity after "tonsillotomy" with modern techniques was first reported in 1999 by Linder et al. [10] and Hultcrantz et al. [11], followed by Densert et al. [12], and Helling et al. [13] in 2001 and 2002, respectively. The results were confirmed with the first large retrospective study in 2003 by Koltai et al. [14] who used a microdebrider as surgical instrument. However, in a small pediatric patient population, a significant impact of "intracapsular tonsillectomy" on OSA—albeit not successful in all patients—was proven by means of polysomnographic

J. P. Windfuhr (✉)
Department of Otorhinolaryngology, Plastic Head and Neck Surgery, Kliniken Maria Hilf Mönchengladbach, Sandradstr 43, 41061 Mönchengladbach, Germany
e-mail: jochen.windfuhr@mariahilf.de

J. A. Werner
Department of Otorhinolaryngology, Head and Neck Surgery, University Hospital Giessen and Marburg, Campus Marburg, Baldingerstr, 35043 Marburg, Germany

studies [15–17] and better OSA-18 Scores [18]. Numerous studies have proven the benefits of intracapsular procedures but failed to replace the role of TE at least in relation to SDB. This is extremely unfortunate, since the decreased postoperative morbidity apparently favors intracapsular procedures.

Two systematic reviews concerning intracapsular tonsillectomies/tonsillotomies were published in the last year. While Walton limited the review to level 1 evidence in the pediatric cohort and SDB as indication for surgery, Acevedo evaluated studies without restrictions by age groups or indication. Walton found the new technique to be superior in recovery-related outcome compared to TE, but Acevedo could not identify any advantages in terms of postoperative bleeding and dehydration. In the light of the selected studies discussed by Acevedo et al. [19] and Walton et al. [20] (Tables 1, 2), the question of standardization raises several points. It should also be clarified whether the more sophisticated approaches for intratonsillar surgery can be replaced by simplified procedures.

Classification of intratonsillar procedures

All intratonsillar techniques aim to avoid exposure or direct injury of the pharyngeal muscles. This happens always with extracapsular techniques which are followed by secondary inflammation caused by bacteria/enzyme-containing saliva. There are different concepts to reduce the size of the tonsils with only two of them acceptable as a true intratonsillar dissection technique with a stepwise resection of tonsillar tissue:

Class 1: Tonsillotomy (TT)

The instrument cuts through the tonsillar tissue to remove only the protruding parts of the tonsil medial to the faucial pillars and stops the reduction at a Brodsky size of 1 [21]. CO_2-LASER, radiofrequency, monopolar needle, cold scissor, and a surgical knife have been applied for this purpose [10–13, 16, 22–30]. The method can be standardized, because the anterior and posterior pillars in the individual patient serve as a landmark for the resection. There were 13 studies with 609 patients in the study groups (10.1 % of all patients studied; Table 1).

The CO_2-LASER is an expensive instrument and the application requires a surgical training program. Radiofrequency devices, monopolar needles, surgical knives or scissors are much cheaper and the handling easier to learn.

Class 2: Subtotal/intracapsular/partial tonsillectomy (SIPT)

The aim of this approach was to remove ~90 % of the tonsil in a stepwise resection of the tonsil from medial to lateral with preservation of a rim of tonsillar tissue as a protection layer along the inner surface of the capsule. Microdebrider, coblation or bipolar scissors/forceps were applied in the different intervention groups [14, 15, 17, 18, 31–52]. The decision, how much to resect from the tonsil and succeed in avoiding perforation of the capsule is widely based on the experience of the surgeon. An anatomical landmark does not exist and therefore the method is hard to be standardized. A total of 5,394 study group patients were enrolled in 26 studies (89.9 % of all patients studied; Table 2).

A microdebrider was used in 77 % of all SIPT studies. The surgical technique is acknowledged for increased intraoperative bleeding compared to monopolar TE that may not be clinically significant [38, 41] but requires control with a monopolar suction cautery [14, 35, 44, 47]. Inadequate use of suction cautery may result in soft tissue trauma. Moreover, there is a risk to injur the pharyngeal muscles owing to the intraoperative bleeding [24]. While the costs of the shaver blade range between $80 [14], $91.20 [48], and $100 [47, 48] per operation, the single-use coblation wand is even more expensive ($140 [52] to $200 [48]). Microdebrider–SIPT has been shown to be advantageous over extracapsular monopolar TE in various outcome measures. For instance, Bitar et al. [43] concluded that his patients returned 2.6× faster to normal activity, stopped taking analgesics 2.8× earlier and returned to normal diet 1.5× quicker compared to monopolar TE.

Not considered equivalent:

1. Automated procedures like guillotine tonsillectomies were historically designed for rapid removal of (parts of) the tonsils at a time, when general anesthesia was not available [53, 54]. Few institutions still use the device [55–58]. A targeted dissection or preservation of the capsule is not a part of the technique.
2. *Radiofrequency-induced thermal therapy*. Shrinkage of the hypertrophic tonsil is achieved by heat application with a bipolar radiofrequency probe at multiple sites and starts after 2 weeks with a peak after 3 months. The technique works without any incision or resection and is therefore not considered equivalent to Class I and II dissection techniques [59–61].

Table 1 Intracapsular tonsillectomy Class I procedures

Author	AT (%)	Intervention group (*n*)	Age range mean median (y)	Instrument	Control group technique	Follow-up	Bleeding (RTT)	Dehydration	Regrowth (%)	Secondary TE (%)	Postop tonsillitis (%)	AB/DX	OP time (min)	Blood loss (ml)
Celenk et al. [25]	ns	42	1–10 4.7 ns	RF	N	14 d; 1, 6–32 m	ns	ns	16.6	11.9	11.9		ns	ns
dela Chaux et al. [16][a]	100	20	2–9 4.1 ± 2 ns	LASER 12–18 W	N	3–12 m	0	ns	ns	ns	ns		ns	ns
Densert et al. [12]	0	20	2–9 5.5 ns	LASER 25 W	C	3, 24 m	0	ns	0	0	0		3–4	ns
Ericsson et al. [26]	84.8	33	4.5–5.5 4.8 ns	RF	C	6 m	0	0 %	ns	3.0	12		ns	ns
Eviatar et al. [30]	0	33	1.3–14 5.4 ns	Monopolar needle	M	10–14 y	0	0 %	3	6.1	6.1		ns	ns
Hultcrantz et al. [11]	14.3	21	3.5–8 ns 6 ± 1.5	LASER 20 W	C	14d; 6 m, 12 m	0	ns	4.8	4.8	0		24.5 ± 11	11 ± 18
Hultcrantz and Ericsson [22]	53.1	49	5–15 ns ns	RF 45 W	C	9 d	PB 4.1 % (2.0 %)	ns	ns	ns	ns		28.3	17.7
Korkmaz et al. [24]	ns	35	2–14 5.45 ± 2.58 ns	Scalpel	C	10 d, 24 m	2.5 % PB (2.5 %)	ns	0	0	ns	+/0	21.3 ± 9.4	44.2 ± 25.5
Linder et al. [10]	48.5	33	1–12 ns 5	LASER 20 W	N	14 d	0	0 %	ns	ns	3		ns	ns
Reichel et al. [23]	89.8	49	2–7 4.5 ns	LASER 15–20 W	C	7 d, 6–24 m	0	ns	5	4.1	0		ns	ns
Stelter et al. [27]	0	26	3–9 ns ns	LASER 16 W RF 16 W	L/RF	3 d	0	ns	ns	ns	ns		8.2 (LASER) 3.9 (RF)	ns
Vlastos et al. [29]	ns	60	1.5–13 4.4 ns	Scissors	C	7 d; 18 m	0.4 % (ns)	ns	10	3.3	ns		ns	ns

Table 1 continued

Author	AT (%)	Intervention group (*n*)	Age range mean median (y)	Instrument	Control group technique	Follow-up	Bleeding (RTT)	Dehydration	Regrowth (%)	Secondary TE (%)	Postop tonsillitis (%)	AB/DX	OP time (min)	Blood loss (ml)
Zagolski [28]	ns	442	3–14 6.7 6.5	Scissors	N	12; 24; 36; 48 m	ns	ns	6.1	4.5	2.7		ns	ns

AT amount of patients undergoing simultaneous adenoidectomy, *RF* radiofrequency, *d* days, *m* months, *y* years, *ns* not stated, *AB* administration of antibiotics, *DX* administration of dexamethasone, *N* no control group, *C* cold steel dissection, *M* microdebrider, *L* LASER, *Co* coblation, *HS* harmonic scalpel, *PB* primary post-tonsillectomy bleeding occurring within the first 24 postoperative hours, *SB* secondary post-tonsillectomy bleeding occurring at any time after the first 24 postoperative hours

[a] Studies including polysomnogram at least in some patients before and/or after surgery

Operation time

Operation time is always an issue at institutions with a great number of procedures per year [35] since operating rooms are billed for $5091 per hour [48]. Operation costs were lowest with microdebrider–SIPT ($2205.20), and more expensive with electrocautery TE ($2825.10) and coblation–SIPT ($2837.10), but have not been calculated for the other instruments [48].

While operation time was not stated for seven Class I procedures, one author stated that the procedure took "less than tonsillectomy's about 2.5 min" [29]. Three authors measured operation times between 21 and 28 min on average [11, 22, 24] and only Densert et al. [12] completed the procedure within 3–4 min.

Fifteen studies with Class II procedures did not measure operation time. Koltai et al. [14] only stated that the microdebrider–SIPT takes "a few minutes longer to perform than total electrocautery tonsillectomy, although the average difference in an informal survey of 20 conservative cases was only 3 min". Other authors completed the procedures within 10–20 [41, 43, 47, 48, 52], 20–30 [32, 35, 45, 46] or more than 30 min [42].

Intraoperative blood loss

Blood loss plays a role particularly in younger patients with limited compensation mechanisms. Concerning Class I techniques, only Hultcrantz and Korkmaz addressed the issue and collected amounts of 11, 17.7, and 44.2 ml on average, respectively [11, 22, 24].

Intraoperative bleeding was specified in only ten Class II procedures, including eight with a microdebrider. The average amounts of blood loss was 16.2 ml after coblation–SIPT [32], <25 ml (in 97 % of patients) [47], 25 ml [43], 27.9 ml [38], 34.8 ml [14], 38.8 ml [46], 44 ml after bipolar forceps–SIPT [45], 45 ml [35], 54.3 ml [41], and 110 ml [42], respectively.

Complications

1. *Edema and upper airway obstruction* It was reported for one patient after monopolar TE and 2 patients (1.3) % after microdebrider–SIPT [47]. Upper airway obstruction that resolved with supplemental oxygen and observation was reported for a third patient (5.3 %) after bipolar–SIPT [45].
2. *Dehydration* Unfortunately, information was not provided for 10 Class I (76.9 %; Table 1) and 10 Class II studies (38.5 %; Table 2). Readmission owing to dehydration was not reported to have happened after

TT [10, 26, 30] or SIPT [15, 18, 31, 32, 34, 36, 43, 45, 46, 52], but occurred in rates of 0.4 % [51], 0.5 % [42], 1.1 % [33, 50], 1.2 % [14], or 5 % [47].

3. *Hemorrhage* Bleeding complications did not occur in the majority of studies after TT (61.5 %) but less than half of the studies after SIPT (46.2 %). Primary bleeding with a return-to-theater after TT was registered in 2.0 % [22] and 2.5 % [24] of patients. Bleeding after SIPT occurred but treatment under general anesthesia was not always required [34, 36, 43, 51]. Return-to-theater was required in rates of 0.5 % [50], 0.67 % [47], and 1.8 % [42], respectively. Hemorrhage rates were not stated for an equal amount of Class I and Class II studies (15.4 %) [17, 25, 28, 37, 38, 49].
4. *Death* It was not reported for any patient in the studies and is unlikely to happen if the dissection is performed within the capsule. Ignoring the rule may be followed by fatal complications [6].

Follow-up, secondary tonsillectomy, regrowth and tonsillitis

According to Arya et al. [62, 63], the pain outcome after coblation–SIPT is not superior compared to coblation-TE. A closer look to the design of his studies revealed that he had followed patients only for the first 24 postoperative hours. His conclusions read different but are not contradictory to the better findings of another study with a follow-up of 6 days [36]. However, the pain score was significantly lower within the first 24 h after TT in the study of Hultcrantz et al. [11]. Unfortunately, the surgical technique of "regular tonsillectomy" was not described, but it can be assumed that it was cold steel TE according to other papers by the same author. The significant better pain scoring within the first 24 postoperative hours and week were confirmed in another study that followed [22].

Follow-up

The example demonstrates the impact of the follow-up rather on the scientific conclusions but not necessarily on the clinical outcome, particularly, if the control group is operated on with different surgical principles (hot vs. cold techniques). In Class I procedures, the follow-up was for the longest ≤1 week [27], ≤2 weeks [10, 22], 6 months [26], 12 months [11, 16], 18 months [29], 24 months [12, 23, 24], 32 months [25], 48 months [28] and 168 months [30], respectively. Patients who had undergone intracapsular Class II techniques were followed for ≤1 week [32, 36, 38, 41, 45, 46], ≤2 weeks [35, 37, 40, 44, 48], 1 month [47], 10 weeks[15], 7.6 months [17], 12 months [14, 18, 31, 34, 52], 18 months [50], 24 months [39], 32 months (median) [42], 36.2 months [43], 72 months [33, 49], respectively. The follow-up was not obtainable from one study [51].

Since some tonsillar tissue remains after intracapsular procedures, there is always a risk of regrowth or tonsillitis deriving from the remnants. Therefore, the follow-up has to cover a postoperative time period sufficient enough to assess the risk of secondary TE to treat regrowth or recurrent tonsillitis.

Secondary TE

The rates of secondary TE following Class I techniques was from 0 % [12, 24], 3 % [26], 3.3 % [29], 4.1 % [23], 4.5 % [28], 4.8 % [11], 6.1 % [30] and 11.9 % [25], respectively. The follow-up period in these studies ranged between 6 months and 14 years. Concerning Class II techniques, rates for revision surgery was between 0 % [39, 43, 52], 0.46 % [33], 0.52 % [50], 0.72 % [34], 1.32 % [42], and 6.7 % [49], respectively. The follow-up period ranged from 1 month to 6 years. No information was obtainable from four TT studies (30.7 %; Table 1) and 18 SIPT studies (69.2 %; Table 2).

Tonsillar regrowth and tonsillitis

Studies reporting of secondary TE also reported rates of tonsillar regrowth (exceptions being [26, 42, 49]) or postoperative tonsillitis (exceptions being [24, 29, 33, 43, 49]). Regrowth rates in the group after TT were from 3 % [30], 4.8 % [11], 5 % [23], 6.1 % [28], 10 % [29], to 16.6 % [25]. Postoperative tonsillitis occurred in rates of 2.7 % [28], 6.1 % [30], 11.9 % [25], and 12 % [26]. Revision surgery after Class II procedures was associated with regrowth that occurred in 0.46 % [33], 0.58 % [50], and 3.24 % [34], respectively. In the revision group, recurrent tonsillitis was reported for 0.36 % [34], 7.3 % [42] to 15.4 % [50] of patients.

Rates of regrowth or tonsillitis were usually higher than the revision rate, indicating that these drawbacks are not always clinically significant.

Tonsillar regrowth occurred within 1–18 months (mean 14.3 months) [25], 6 months [11], 10 months [23], within 18 months [29] or within 2–4 (mean 3.8 years) [28] or 10–14 years [30] after Class I procedures. Class II procedures were associated with tonsillar regrowth after a mean and median length of 19 months "several months after PITA" [50], or "usually during the first or second postoperative year" [33].

Table 2 Intracapsular tonsillectomy Class II procedures

Author	AT (%)	Intervention group (n)	Age range mean median (y)	Instrument	Control group technique	Follow-up	Bleeding (RTT)	Dehydration (%)	Regrowth	Secondary TE	Postop tonsillitis	AB/DX	OP time (min)	Blood loss (ml)
Bent et al. [31]	ns	38	17–36 m 30.3 m 31 m	M	M	14 d–12 m	0	0	ns	ns	ns	+/+	ns	ns
Bitar et al. [43]	86.6	77	1–7 3.76 ± 1.34 ns	M	M	14 d; 1–36.2 m; mean: 20; median: 20.6	1.3 % 0	0	0	0	ns	+/+	14.8 ± 3.81	25
Chan et al. [52]	ns	27	3–12 ns ns	Co	M	14d; 3 m; 12 m	0	0	0	0	0	+/+	19.5 ± 10.9	ns
Chang [32]	98.1	52	ns 6.4 ± 3.5 ns	Co	M	6 d	0	0	ns	ns	ns	ns	28.5 ± 19.1	16.2 ± 27.2
Chang [36]	100	34	2–16 6.2 ns	Co	Co	6 d	2.9 % 0	0	ns	ns	ns	ns	ns	ns
Cohen et al. [37]	ns	16	5–19 9.92 ± 4.86 ns	Bipolar scissors	Bipol Sc	14 d	ns	ns	ns	ns	ns	+/+	ns	ns
Colen et al. [18][a]	100	50	1–12 4.5 ns	M	N	3, 12 m	0	0	ns	ns	ns	+/+	ns	ns
Derkay et al. [47]	ns	150	>2 y 5 ± 4.7 ns	M	M	1 m	1.33 % 0.67 %	5	ns	ns	ns	+/+	10	<25 ml (97 %)
Friedman et al. [17][a]	100	159	4–18 8.5 ± 3.1 ns	Co	N	Mean 6.4 m ± 1.2 m	ns	ns	ns	ns	ns	ns	ns	ns
Gallagher et al. [51]	ns	824	1–18 5 ns	M	M/Co	ns	0.36 % 0	0.4	ns	ns	ns	ns	ns	ns
Gan et al. [40]	85.6	305	<17 6.5 ± 3.2 ns	M	Bipol forceps	14d	0.98 % ns	ns	ns	ns	ns	ns	ns	ns
Johnston et al. [42]	ns	218	>12 y 23.1 ns	M	M	2 m, median 32 m	ns 1.8 %	0.5	ns	1.32 %	7.3 %	ns	35.4 (15–90)	110/ (30–300)

Table 2 continued

Author	AT (%)	Intervention group (n)	Age range mean median (y)	Instrument	Control group technique	Follow-up	Bleeding (RTT)	Dehydration (%)	Regrowth	Secondary TE	Postop tonsillitis	AB/DX	OP time (min)	Blood loss (ml)
Koltai et al. [14]	ns	243	ns 6.1 ± 3.0 ns	M	M	9 d, 1–12 m	1.7 % ns	1.2	0	ns	0	ns	"3 min longer than TE"	34.8 ± 44.5
Lister et al. [44]	88	25	5–15 8.08 ± 2.68 ns	M	M	14 d	0	ns	ns	ns	ns	+/+	ns	ns
Mangiardi et al. [49][a]	100	15	1.3–13.92 5.33 ± 3.65 ns	M	M	1–6 y	ns	ns	ns	6.7 %	ns	ns	ns	ns
Mixson et al. [46]	ns	54	2–17 ns ns	M	M/HS	7 d	0	0	ns	ns	ns	ns	20.3	38.8
Nguyen et al. [38]	ns	57	<19 5.4 ± 2.7 ns	M	M	Day of surgery	ns	ns	ns	ns	ns	+/+	ns	27.9 ± 42.5
Park et al. [45]	ns	19	2–12 6.4 ns	Bipolar forceps	M	7 d	0	0	ns	ns	ns	+/+	27 ± 8	44 ± 32
Pruegsanusak et al. [41]	90	20	3–11 6.30 ± 3.15 ns	M	C	6 d	0	ns	ns	ns	ns	+/0	15.53 ± 8.42	54.3 ± 35.45
Reilly et al. [39][a]	100	26	1.5–15 5.6 ns	M	M	24 m	0	ns	0	0	0	ns	ns	ns
Schmidt et al. [50]	ns	1,731	ns 6 ns	M	M	18 m	0.11 % PB, 1.1 % SB 0.5 %	1.1	0.58 %	0.52 %	15.4 %	ns	ns	ns
Sobol et al. [35]	100	38	3–7 ns ns	M	M	10 d	0	ns	ns	ns	ns	+/+	20.9 ± 4.4	45 ± 29.4
Solares et al. [33]	ns	870	ns	M	M	0.1–2.6 y (median 1.2 y)	0.57 %	1.1	0.46 %	0.46 %	ns		ns	ns
Sorin et al. [34]	100	278	17 m–14.4 y 4.7 y ± 21 m ns	M	N	1–12 m	0.72 % 0	0	3.24 %	0.72 %	0.36 %	+/+	ns	ns

Table 2 continued

Author	AT (%)	Intervention group (n)	Age range mean median (y)	Instrument	Control group technique	Follow-up	Bleeding (RTT)	Dehydration (%)	Regrowth	Secondary TE	Postop tonsillitis	AB/DX	OP time (min)	Blood loss (ml)
Tunkel et al. [15][a]	100	14	2.33–9.42 5.92 ns	M	N	5–10 weeks (median: 6 weeks)	0	0	ns	ns	ns	+/0	ns	ns
Wilson et al. [48]	100	49	<2–>18 6.1 ns	M	M/Co	<14 d	0	ns	ns	ns	ns	+/+	16.1 ± 4.91	ns

AT amount of patients undergoing simultaneous adenoidectomy, *RF* radiofrequency, *d* days, *m* months, *y* years, *ns* not stated, *AB* administration of antibiotics, *DX* administration of dexamethasone, *N* no control group, *C* cold steel dissection, *M* microdebrider, *L* LASER, *Co* coblation, *HS* harmonic scalpel, *PB* primary post-tonsillectomy bleeding occurring within the first 24 postoperative hours, *SB* secondary post-tonsillectomy bleeding occurring at any time after the first 24 postoperative hours

[a] Studies including polysomnogram at least in some patients before and/or after surgery

Tonsillitis following Class I procedures was reported to have occurred within the first 6 months [26], 1–17 months [25], after 20 months [10], within 4 years [28], or 10–14 years [30]. Recurrent tonsillitis after Class II procedures occurred after 3–9 months [42], within 12 months [34], or within 18 months [50].

Celenk et al. [25] speculated that, at an age <4 years, TT or previous episodes of tonsillitis should be considered as risk factors for tonsillar regrowth. In Bitar et al. [43], 43.1 % of all patients were younger than 3 years of age and tonsillar regrowth was not observed within a 2-year follow-up. Schmidt et al. [50] reported 11 secondary TEs, 10 with hypertrophy and 1 with both hypertrophy and tonsillitis as primary diagnosis. Regrowth was registered by Sorin et al. [34] in 3.24 % after 278 SIPT procedures, but encompasses 50 % of children with an age >4 years. It should also be noted that tonsillar remnants may be found even after extracapsular TE [30, 49]. Moreover, a history of tonsillitis appears not to be a valid exclusion criterion (see below).

Unvalidated adjuvant therapy

Antibiotics and steroids

Antibiotics and steroids were given for at least 5 days [15, 18, 24, 31, 34, 35, 37, 38, 41, 43–45, 47, 48, 52] including intraoperative administration of dexamethasone or a non-specified steroid [48] in all but three studies [15, 24, 41]. With one exception [24], all studies analyzed Class II procedures.

Injection of medical agents

Linder injected 5 ml of 2.5 mg/ml bupivacaine with epinephrine at each side [10]. Hultcrantz et al. [11] relied on that technique but later injected an amount of only 2–3 ml of the same agent [22]. Derkay et al. [47] injected 10 ml of the same agent into both anterior facial pillars and Passavant′s ridge before and into the posterior pillar and the tongue base after SIPT with a microdebrider. An unspecified amount of 0.25 % marcaine with 1:200.000 epinephrine was injected at the end of the surgical procedure into the anterior and posterior pillars by Wilson et al. [48]. Pruegsanusak et al. [41] injected 0.25 % bupivacaine with adrenaline 1:200.000 into the anterior pillar and tongue base prior to surgery. Densert et al. [12] injected an unspecified amount of 0.25 % marcaine with epinephrine into the superior and inferior tonsil poles. Mixson et al. [46] applied bismuth and approximated the anterior and posterior pillars with a suture.

It needs further research to clarify the true benefit of adjuvant therapy.

Unvalidated exclusion criteria

Tonsillitis in the history

A history of tonsillitis was an exclusion criterion in the first study from Sweden [10] but later abandoned [22]. Koltai et al. [14] argued that tonsillar regrowth may be followed by tonsillitis and therefore excluded patients with a history of chronic tonsillitis but provided no exact definition of that term. He supported his statement with a single citation dating back to 1917. Derkay et al. [47] recommended not to include patients with a history of tonsillitis because of the unknown incidence of tonsillitis following SIPT at the time of his publication. Reichel et al. [23] stated, "in Germany TT is strictly contraindicated in patients with recurrent throat infections". A total of 14 authors (35.9 %) excluded patients with a history of tonsillitis for Class I [10, 11, 16, 23, 24, 26] or Class II procedures [14, 39, 41, 44–47, 49]. Despite these concerns, Chan et al. [52] included patients if they reported two or fewer episodes of streptococcal pharyngitis per year. Chang [32, 36] excluded children and adolescents only if they reported "significant" history of tonsillitis. Other authors counted the bouts of tonsillitis and excluded patients with more than three episodes of tonsillitis per year [15, 34] or indication for TE as suggested by Paradise et al. [43, 64]. In the large patient population analyzed by Schmidt et al. [50], patients with a history of tonsillitis were included as in other studies [17, 38, 47]. Johnston et al. [42] explicitly performed microdebrider–SIPT to treat tonsillitis, with or without hypertrophy, in 191 adult patients and finally performed secondary TE in 4 (2.1 %) of them. In the study of Ericsson et al. [26], evidence is given that TT is capable of treating patients suffering from tonsillitis without any adverse events in the 1-year follow-up.

Age >8 years

It has been stated that tonsillotomy procedures should be limited to 6- or 8-year-old children [13, 65, 66]. These statements are not supported by the vast majority of studies. In only 15.4 % of all studies, patients older than 8 years of age were excluded for Class I [11, 23, 26] or Class II procedures [31, 35, 43]. Insufficient information about the age distribution was provided by two authors [33, 50]. Sobol et al. [35] excluded children younger than 3 years owing to the higher risk of complications following TE and children older than 7 years to allow the use of one standard pain rating scale for all children. It should be noted that the outcome of TT after 1 year was comparable to TE in patients aged between 16 and 25 years, explicitly to resolve recurrent tonsillitis [67].

Confounding factors

Study design

- Conclusions drawn from retrospective studies are always limited, since patients are not randomly assigned and groups are therefore not equal.
- The different sizes of the study groups make comparison difficult. The size of the study groups after TT varied from 20 to 442 (mean 66.38, median 33, STD 113.5, Table 1), while the size after SIPT ranged between 14 and 1731 (mean 207.26, median 51, STD 382.99; Table 2).
- The effect of aging with the associated considerable anatomical changes, particularly in children and adolescents, are presumably underestimated factors.
- Counseling of parents concerning reduced postoperative morbidity after TT or SIPT may raise expectations and bias assessment of outcome.
- Differences in methods of anesthesia, recovery room protocols, intra-postoperative medication make comparison difficult.
- It can only be assumed that the learning curve for TT and SIPT procedures is different and therefore surgical experience needs to be standardized.
- Conclusions based on questionnaires are always complicated by recall and survey bias [14, 46].
- Comparing pain in children of varying ages is difficult [35].
- The surgical technique of the control group is likely to bias conclusions. At least by the clear evidence of a dose–response relationship between electrosurgical energy and postoperative pain by Cardozo et al. [68], it appears self-evident that the surgical technique used in the study of Park et al. [45] is unable to result in less pain compared to monopolar TE. Moreover, electrosurgery has been identified as a risk factor for post-tonsillectomy hemorrhage in extensive studies [69, 70]. Some studies were not designed with a control group (Class I 30.8 %, Class II 15.4 %). Surgical techniques applied in studies with control groups (Class I vs. Class II) encompassed cold dissection (77.8 vs. 4.5 %), LASER/radiofrequency (11.1 vs. 0 %), monopolar electrosurgery (11.1 vs. 77.3 %), bipolar surgery (0 vs. 9.1 %), coblation (0 vs. 13.6 %), harmonic scalpel (0 vs. 4.5 %), and microdebrider in different age groups (0 vs. 4.5 %).
- *Concomitant adenoidectomy*. In Class I procedures, Densert et al. [12] indicated TT only in children, when symptoms of OSA persisted for 3–4 months after previous adenoidectomy. Four publications did not mention as to whether adenoidectomy was performed or not [24, 25, 28, 29]. A simultaneous adenoidectomy

was an exclusion criterion for some authors [27, 30], performed in every single patient [16] or performed in 14.3 % [11], 48.5 % [10], 53.1 % [22], 84.8 % [26], 89.8 % [23] of all children of the intervention group, respectively. For Class II procedures, information was not obtainable from 12 publications [14, 31–33, 37, 38, 45–47, 50–52]. The remainder included concomitant adenoidectomy in 85.6 % [40], 86.6 % [43], 88 % [44], 90 % [41], 98.1 % [32], 100 % [15, 17, 18, 34–36, 39, 48, 49], respectively, of the study group.

- *Polysomnography*. Emphasis on polysomnographic studies was obtainable from only few studies [15–18, 39, 49] revealing significant improvements in the PSG findings after intracapsular tonsil surgery. Tunkel et al. [15] addressed the issue of the short-term evaluation of his study, only 4–8 weeks after SIPT. It should be noted that some authors [49] accepted an AHI < 5 as successful outcome which is not accepted by Friedman et al. [17] who postulated that success is defined by an AHI < 1. Moreover, a definition of short-term and long-term success needs to be clarified [15]. Mangiardi et al. [49] addressed the validity of home PSG, since none of his 30 patients had an AHI < 1 after TE or microdebrider–SIPT.

Individual parameters

- Underlying diseases, like allergy, retroposition of the mandible, enlarged inferior turbinates, or septal deviation [15] need to be adequately addressed.
- Whether or not a high sugar diet is a risk factor for tonsillar regrowth [28] remains to be clarified. Mangiardi et al. [49] could exclude obesity, an increased BMI, age, sleep study indices and tonsil size as confounding factors, but his conclusions are limited by the small study size ($n = 15$ per arm) and retrospective study design. The issue of body mass index, Mallampati score and severity of OSA was addressed at least by Tunkel et al. and Friedman et al. [15, 17], since they have been proven to have a promising predictive value for successful outcome.

Conclusions

1. Comparison of the numerous studies is complicated by the heterogeneity in the study design, available raw data and outcome measures.
2. There are no studies revealing that intratonsillar surgery is associated with a poorer outcome concerning pain, required intake of oral analgesics, return to normal diet and activity compared to extracapsular surgery. For only few cases, the worst result would be a comparable outcome as after TE or revision surgery in a small number of patients. This also translates into an earlier return-to-work for the primary caregiver for the majority of patient families.
3. TT and SIPT are not complicated by higher incidences of dehydration or postoperative bleeding, with or without surgical intervention, compared to TE.
4. Microdebrider–SIPT is more likely to result in an increased intraoperative bleeding compared to electrocautery TE.
5. Superior results are not associated with one of the more sophisticated and expensive techniques, such as CO_2-LASER, microdebrider, coblation, or radiofrequency.
6. TT and SIPT are not a kind of surgery limited by age with a clear cut-off value.
7. A history of tonsillitis is not a contraindication for TT or SIPT. The term "significant" tonsillitis is without definition. It is remains debatable as to whether statements for children are transferrable for adults.
8. Regrowth of tonsillar tissue may occur after TT, SIPT and even TE. The issue has to be mentioned in the informed consent/assent. It remains unclear as to whether or not regrowth of tonsillar tissue is clinically significant. Detection of regrowth is based on the length of the follow-up.
9. TE does not guarantee successful treatment of OSA. TT or SIPT is not associated with inferior results. The pathophysiology of SBD and OSAS particularly in children is complex. Therefore, studies including pre- and postoperative PSG are required.
10. Less-expensive cold steel surgical instruments (knife, scissors) are apparently attractive owing to the simple, safe and cost-effective approach and need to be compared with the more sophisticated, expensive devices.
11. Current TE guidelines inadequately apply to intracapsular procedures. Therefore, prospective, randomized clinical trials with adequate follow-up to achieve high-quality published evidence on these techniques are mandatory.

References

1. Koempel J (2002) On the origin of tonsillectomy and the dissection method. Laryngoscope 112:1583–1586
2. Koempel JA, Solares CA, Koltai PJ (2006) The evolution of tonsil surgery and rethinking the surgical approach to obstructive sleep-disordered breathing in children. J Laryngol Otol 120:993–1000
3. Rosenfeld RM, Green RP (1990) Tonsillectomy and adenoidectomy: changing trends. Ann Otol Rhinol Laryngol 99:187–191

4. Parker NP, Walner DL (2011) Trends in the indications for pediatric tonsillectomy or adenotonsillectomy. Int J Pediatr Otorhinolaryngol 75:282–285
5. Baugh RF, Archer SM, Mitchell RB et al (2011) Clinical practice guideline: tonsillectomy in children. Otolaryngol Head Neck Surg 144:S1–S30
6. Windfuhr JP, Schloendorff G, Sesterhenn AM et al (2009) A devastating outcome after adenoidectomy and tonsillectomy: ideas for improved prevention and management. Otolaryngol Head Neck Surg 140:191–196
7. Windfuhr JP, Schloendorff G, Baburi D et al (2008) Serious post-tonsillectomy hemorrhage with and without lethal outcome in children and adolescents. Int J Pediatr Otorhinolaryngol 72:1029–1040
8. Lantsov AA, Kovaleva LM (1993) A method of organ-preserving tonsillotomy. Vestn Otorinolaringol 5–6:39–42
9. Krespi YP, Ling EH (1994) Laser-assisted serial tonsillectomy. J Otolaryngol 23:325–327
10. Linder A, Markstrom A, Hultcrantz E (1999) Using the carbon dioxide laser for tonsillotomy in children. Int J Pediatr Otorhinolaryngol 50:31–36
11. Hultcrantz E, Linder A, Markstrom A (1999) Tonsillectomy or tonsillotomy?–A randomized study comparing postoperative pain and long-term effects. Int J Pediatr Otorhinolaryngol 51:171–176
12. Densert O, Desai H, Eliasson A et al (2001) Tonsillotomy in children with tonsillar hypertrophy. Acta Otolaryngol 121:854–858
13. Helling K, Abrams J, Bertram WK et al (2002) Laser tonsillotomy-a method for treating tonsillar hyperplasia in early childhood. HNO 50:470–478
14. Koltai P, Solares C, Koempel J et al (2003) Intracapsular tonsillar reduction (partial tonsillectomy): reviving a historical procedure for obstructive sleep disordered breathing in children. Otolaryngol Head Neck Surg 129:532–538
15. Tunkel DE, Hotchkiss KS, Carson KA et al (2008) Efficacy of powered intracapsular tonsillectomy and adenoidectomy. Laryngoscope 118:1295–1302
16. de la Chaux R, Klemens C, Patscheider M et al (2008) Tonsillotomy in the treatment of obstructive sleep apnea syndrome in children: polysomnographic results. Int J Pediatr Otorhinolaryngol 72:1411–1417
17. Friedman M, Wilson MN, Friedman J et al (2009) Intracapsular coblation tonsillectomy and adenoidectomy for the treatment of pediatric obstructive sleep apnea/hypopnea syndrome. Otolaryngol Head Neck Surg 140:358–362
18. Colen TY, Seidman C, Weedon J et al (2008) Effect of intracapsular tonsillectomy on quality of life for children with obstructive sleep-disordered breathing. Arch Otolaryngol Head Neck Surg 134:124–127
19. Acevedo JL, Shah RK, Brietzke SE (2012) Systematic review of complications of tonsillotomy versus tonsillectomy. Otolaryngol Head Neck Surg 146:871–879
20. Walton J, Ebner Y, Stewart MG et al (2012) Systematic review of randomized controlled trials comparing intracapsular tonsillectomy with total tonsillectomy in a pediatric population. Arch Otolaryngol Head Neck Surg 138:243–249
21. Brodsky L (1989) Modern assessment of tonsils and adenoids. Pediatr Clin North Am 36:1551–1569
22. Hultcrantz E, Ericsson E (2004) Pediatric tonsillotomy with the radiofrequency technique: less morbidity and pain. Laryngoscope 114:871–877
23. Reichel O, Mayr D, Winterhoff J et al (2007) Tonsillotomy or tonsillectomy?–a prospective study comparing histological and immunological findings in recurrent tonsillitis and tonsillar hyperplasia. Eur Arch Otorhinolaryngol 264:277–284
24. Korkmaz O, Bektas D, Cobanoglu B et al (2008) Partial tonsillectomy with scalpel in children with obstructive tonsillar hypertrophy. Int J Pediatr Otorhinolaryngol 72:1007–1012
25. Celenk F, Bayazit YA, Yilmaz M et al (2008) Tonsillar regrowth following partial tonsillectomy with radiofrequency. Int J Pediatr Otorhinolaryngol 72:19–22
26. Ericsson E, Lundeborg I, Hultcrantz E (2009) Child behavior and quality of life before and after tonsillotomy versus tonsillectomy. Int J Pediatr Otorhinolaryngol 73:1254–1262
27. Stelter K, de la Chaux R, Patscheider M et al (2010) Double-blind, randomised, controlled study of post-operative pain in children undergoing radiofrequency tonsillotomy versus laser tonsillotomy. J Laryngol Otol 124:880–885
28. Zagolski O (2010) Why do palatine tonsils grow back after partial tonsillectomy in children? Eur Arch Otorhinolaryngol 267:1613–1617
29. Vlastos IM, Parpounas K, Economides J et al (2008) Tonsillectomy versus tonsillotomy performed with scissors in children with tonsillar hypertrophy. Int J Pediatr Otorhinolaryngol 72:857–863
30. Eviatar E, Kessler A, Shlamkovitch N et al (2009) Tonsillectomy vs. partial tonsillectomy for OSAS in children—10 years post-surgery follow-up. Int J Pediatr Otorhinolaryngol 73:637–640
31. Bent JP, April MM, Ward RF et al (2004) Ambulatory powered intracapsular tonsillectomy and adenoidectomy in children younger than 3 years. Arch Otolaryngol Head Neck Surg 130:1197–1200
32. Chang KW (2005) Randomized controlled trial of Coblation versus electrocautery tonsillectomy. Otolaryngol Head Neck Surg 132:273–280
33. Solares CA, Koempel JA, Hirose K et al (2005) Safety and efficacy of powered intracapsular tonsillectomy in children: a multi-center retrospective case series. Int J Pediatr Otorhinolaryngol 69:21–26
34. Sorin A, Bent JP, April MM et al (2004) Complications of microdebrider-assisted powered intracapsular tonsillectomy and adenoidectomy. Laryngoscope 114:297–300
35. Sobol SE, Wetmore RF, Marsh RR et al (2006) Postoperative recovery after microdebrider intracapsular or monopolar electrocautery tonsillectomy: a prospective, randomized, single-blinded study. Arch Otolaryngol Head Neck Surg 132:270–274
36. Chang KW (2008) Intracapsular versus subcapsular coblation tonsillectomy. Otolaryngol Head Neck Surg 138:153–157
37. Cohen MS, Getz AE, Isaacson G et al (2007) Intracapsular vs. Extracapsular Tonsillectomy: a Comparison of Pain. Laryngoscope 117:1855–1858
38. Nguyen CV, Parikh SR, Bent JP (2009) Comparison of intraoperative bleeding between microdebrider intracapsular tonsillectomy and electrocautery tonsillectomy. Ann Otol Rhinol Laryngol 118:698–702
39. Reilly BK, Levin J, Sheldon S et al (2009) Efficacy of microdebrider intracapsular adenotonsillectomy as validated by polysomnography. Laryngoscope 119:1391–1393
40. Gan K, Tomlinson C, El-Hakim H (2009) Post-operative bleeding is less after partial intracapsular tonsillectomy than bipolar total procedure. Int J Pediatr Otorhinolaryngol 73:667–670
41. Pruegsanusak K, Wongsuwan K, Wongkittithawon J (2010) A randomized controlled trial for perioperative morbidity in microdebrider versus cold instrument dissection tonsillectomy. J Med Assoc Thai 93:558–565
42. Johnston DR, Gaslin M, Boon M et al (2010) Postoperative complications of powered intracapsular tonsillectomy and monopolar electrocautery tonsillectomy in teens versus adults. Ann Otol Rhinol Laryngol 119:485–489
43. Bitar MA, Rameh C (2008) Microdebrider-assisted partial tonsillectomy: short- and long-term outcomes. Eur Arch Otorhinolaryngol 265:459–463

44. Lister MT, Cunningham MJ, Benjamin B et al (2006) Microdebrider tonsillotomy vs electrosurgical tonsillectomy: a randomized, double-blind, paired control study of postoperative pain. Arch Otolaryngol Head Neck Surg 132:599–604
45. Park A, Proctor MD, Alder S et al (2007) Subtotal bipolar tonsillectomy does not decrease postoperative pain compared to total monopolar tonsillectomy. Int J Pediatr Otorhinolaryngol 71:1205–1210
46. Mixson CM, Weinberger PM, Austin MB (2007) Comparison of microdebrider subcapsular tonsillectomy to harmonic scalpel and electrocautery total tonsillectomy. Am J Otolaryngol 28:13–17
47. Derkay CS, Darrow DH, Welch C et al (2006) Post-tonsillectomy morbidity and quality of life in pediatric patients with obstructive tonsils and adenoid: microdebrider vs electrocautery. Otolaryngol Head Neck Surg 134:114–120
48. Wilson YL, Merer DM, Moscatello AL (2009) Comparison of three common tonsillectomy techniques: a prospective randomized, double-blinded clinical study. Laryngoscope 119:162–170
49. Mangiardi J, Graw-Panzer KD, Weedon J et al (2010) Polysomnography outcomes for partial intracapsular versus total tonsillectomy. Int J Pediatr Otorhinolaryngol 74:1361–1366
50. Schmidt R, Herzog A, Cook S et al (2007) Complications of tonsillectomy: a comparison of techniques. Arch Otolaryngol Head Neck Surg 133:925–928
51. Gallagher TQ, Wilcox L, McGuire E et al (2010) Analyzing factors associated with major complications after adenotonsillectomy in 4776 patients: comparing three tonsillectomy techniques. Otolaryngol Head Neck Surg 142:886–892
52. Chan KH, Friedman NR, Allen GC et al (2004) Randomized, controlled, multisite study of intracapsular tonsillectomy using low-temperature plasma excision. Arch Otolaryngol Head Neck Surg 130:1303–1307
53. Physick PS (1828) Case of obstinate cough, occasioned by elongation of the uvula, in which a portion of that organ was cut off, with a description of the instrument employed for that purpose, and also for excision of scirrhous tonsils. Am J Med Sciences 1:262–265
54. Sluder G (1910) Tonsillectomy by means of the alveolar eminence of the mandible and a guillotine with a review of collateral issues. JAMA LV:60
55. Kretzschmar MJ, Siccama I, Houweling PL et al (2010) Hypoxaemia and bradycardia in children during guillotine adenotonsillectomy without intubation. Ned Tijdschr Geneeskd 154:A1889
56. Homer JJ, Williams BT, Semple P et al (2000) Tonsillectomy by guillotine is less painful than by dissection. Int J Pediatr Otorhinolaryngol 52:25–29
57. Sunkaraneni VS, Ismail-Koch H, Salib RJ et al (2009) Guillotine tonsillectomy: a neglected technique. J Laryngol Otol 123:907–909
58. Mathews J, Lancaster J, Sherman I et al (2002) Guillotine tonsillectomy: a glimpse into its history and current status in the United Kingdom. J Laryngol Otol 116:988–991
59. Nemati S, Banan R, Kousha A (2010) Bipolar radiofrequency tonsillotomy compared with traditional cold dissection tonsillectomy in adults with recurrent tonsillitis. Otolaryngol Head Neck Surg 143:42–47
60. Coticchia JM, Yun RD, Nelson L et al (2006) Temperature-controlled radiofrequency treatment of tonsillar hypertrophy for reduction of upper airway obstruction in pediatric patients. Arch Otolaryngol Head Neck Surg 132:425–430
61. Nelson LM (2003) Temperature-controlled radiofrequency tonsil reduction in children. Arch Otolaryngol Head Neck Surg 129:533–537
62. Arya A, Donne AJ, Nigam A (2003) Double-blind randomized controlled study of coblation tonsillotomy versus coblation tonsillectomy on postoperative pain. Clin Otolaryngol Allied Sci 28:503–506
63. Arya AK, Donne A, Nigam A (2005) Double-blind randomized controlled study of coblation tonsillotomy versus coblation tonsillectomy on postoperative pain in children. Clin Otolaryngol 30:226–229
64. Paradise JL, Bluestone CD, Bachman RZ et al (1984) Efficacy of tonsillectomy for recurrent throat infection in severely affected children. Results of parallel randomized and nonrandomized clinical trials. N Engl J Med 310:674–683
65. Gronau S, Fischer Y (2005) Tonsillotomy. Laryngorhinootologie 84:685–690 quiz 691–694
66. Scherer H (2003) Tonsillotomy versus Tonsillectomy. Laryngorhinootologie 82:754–755
67. Ericsson E, Ledin T, Hultcrantz E (2007) Long-term improvement of quality of life as a result of tonsillotomy (with radiofrequency technique) and tonsillectomy in youths. Laryngoscope 117:1272–1279
68. Cardozo AA, Hallikeri C, Lawrence H et al (2007) Teenage and adult tonsillectomy: dose-response relationship between diathermy energy used and morbidity. Clin Otolaryngol 32:366–371
69. Lowe D, van der Meulen J (2004) Tonsillectomy technique as a risk factor for postoperative haemorrhage. Lancet 364:697–702
70. Sarny S, Ossimitz G, Habermann W et al (2011) Hemorrhage following tonsil surgery: a multicenter prospective study. Laryngoscope 121:2553–2560