

# Systematic review on treatment of Zenker's diverticulum

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Received: 16 May 2014 / Accepted: 29 August 2014 / Published online: 7 September 2014  
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**Abstract** This study was designed to compare rates of failure, revision and morbidity from endoscopic and open approaches as treatment for pharyngeal pouch. Systematic review was conducted using MEDLINE and PubMed databases. Search terms treatment, Zenker's, hypopharyngeal, pharyngeal, diverticulum, and pouch. There were no randomised clinical trials. Therefore, cohort and comparative studies with at least 10 patients in each arm, a follow-up of a least 12 months and reporting on all patients were included. Seventy-one studies met inclusion criteria. Diverticulectomy with or without cricopharyngeal myotomy comprised 33 studies (1,990 patients), and endoscopic stapler diverticulotomy was in 22 studies (1,089 patients). Failure of open and endoscopic approaches was 4.2 and 18.4 %, respectively, and corresponding complication rates were 11 and 7 %. Within endoscopic techniques, failure rates were 18.9 % for stapler diverticulotomy and 21.7 % for laser diverticulotomy. Corresponding complication rates were 4.3 and 7.9 %. Flexible endoscopy techniques have a higher failure (29 %) and overall complication rate (14.3 %). Most reported complications for transcervical techniques relate to the recurrent nerve (3.4 %) and salivary fistula (3.7 %) and for endoscopic group emphysema (3.0 %) and mediastinitis (1.2 %). Operation-related deaths

were infrequent in both groups, but more frequent with open approach (0.9 vs. 0.4 %). Open approaches have more success but more complications than endoscopic techniques. Taking in account overall complications and failure rates, open approaches and stapler diverticulotomy yield different patterns, but are arguably comparable. In younger patients open approach is preferred, as well in patients with unfavourable anatomic conditions for endoscopic exposure. Flexible endoscopic techniques provide a suitable option for patients who do not tolerate general anaesthesia.

**Keywords** Zenker · Diverticulum · Pouch · Treatment · Review

## Background

A Zenker's diverticulum or pharyngeal pouch originates from a dehiscence in Killian's triangle due to a dysfunction of the cricopharyngeal muscle. Over the last 20 years, the treatment of pharyngeal pouch has shifted from open transcervical towards endoscopic transoral therapy. With the introduction of the stapling device in 1993 [1, 2], endoscopic stapling diverticulotomy has become increasingly popular.

Although there is a lack of randomised clinical trials, surgeons favour endoscopic techniques as they seem to have a similar outcome causing less morbidity. Lang et al. [3] in 2007 published a 2.6 % morbidity rate with endoscopic stapling diverticulotomy, as compared to 7.4 % with laser and 11.8 % with open transcervical approach. Additionally, they reported a reduced mean time to start on a normal diet, a shorter mean length of hospital stay and reduced relapse rate, when compared to conventional open techniques.

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In 2012, to formulate minimal clinical standards and recommendations of best practice, Leong et al. [4] noted that 83 % of surgeons in the UK regard endoscopic stapling diverticulotomy as first choice treatment of pharyngeal pouch, and they performed a review of outcomes of endoscopic stapling diverticulotomy in the UK, collecting 585 patients for meta-analysis. They reported an intra-operative failure of 7.7 %, overall complication rate of 9.8 % and recurrence rate of 12.8 %. The most common reason to abandon the procedure intra-operatively was difficulty accessing the small pouch (in 42 % of failed cases). Difficult exposure due to a stiff cervical spine (27 %) and prominent dentition (18 %) were other factors. The most common major complication was perforation of the oesophagus or pouch (4.8 %). One death was reported.

Although most surgeons seem to regard endoscopic stapling as first choice treatment, the combination of recurrence and difficulties with exposure can account for an overall failure of more than 20 % with this approach. Our own preference has been for the diverticulum to be managed by an external cervical approach (sac inversion). Therefore, we decided to examine and compare the current available literature to compare the evidence base regarding failure, complications and morbidity for endoscopic and cervical approaches for Zenker's diverticulum.

## Methods

A systematic review was performed in November 2012 searching the PubMed, MEDLINE and Cochrane databases using the search terms 'Zenker's diverticulum or hypopharyngeal diverticulum or pharyngeal pouch and treatment' in combination with a search of bibliography of retrieved papers. Studies were included using quality criteria based on the PRISMA 2009 checklist and STROBE

statement. These inclusion criteria were at least 10 patients, a mean follow-up of at least 1 year, reporting on all patients, mean follow-up period and proportion lost to follow-up. Papers before 1980 were excluded.

To compare different groups, we used the statistical programme SPSS and non-parametric tests, Mann–Whitney test and Kruskal–Wallis test. *p* values of 0.05 or less were assumed statistically significant for the comparisons.

Primary outcome was failure to successfully manage the pouch and resolve the dysphagia. Secondary outcomes were complications, hospital stay, long-term recurrence and short-term failure including intra-operative failure as well as postoperative persistence of symptoms with early recurrence. Noted complications were fistula, emphysema, recurrent nerve palsy, mediastinitis, haematoma, stenosis and death.

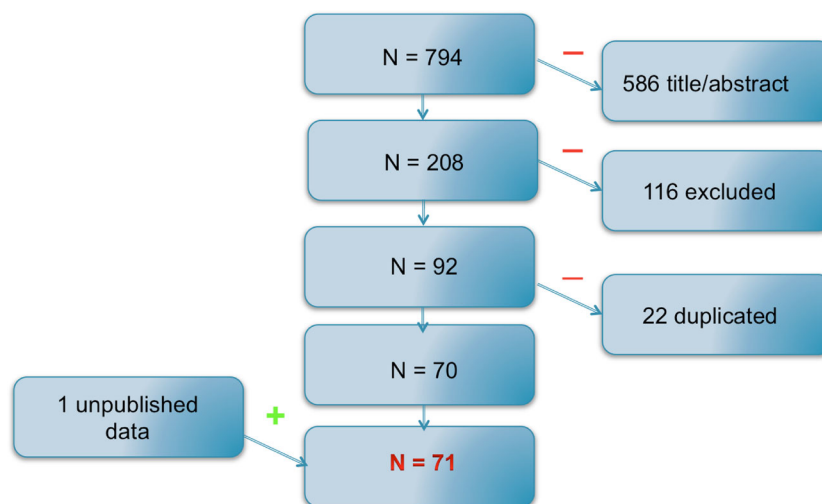
## Results

### Included papers

The search provided 794 potentially relevant articles. English, French, German and Spanish papers were included. After relevance for title and abstract 586 papers were excluded. The two authors blinded to each other read 208 selected papers. As there were no randomised clinical trials, only cohort and comparative studies were retrieved; 70 series met inclusion criteria and one clinical series of unpublished data was added (Fig. 1).

There were 28 comparative studies and 43 cohort studies. Most comparative studies involved different external approaches (13 publications). Nine papers compared experience between endoscopic and external approaches; five compared various endoscopic techniques, and one study compared several different endoscopic as well as

**Fig. 1** Number of retrieved papers and order of selection. *Right column* shows number of excluded papers and reason. *Left column* shows number of added series. *N* number



**Table 1** Excision

Reference	nr Patients	Study	Fail tot	Fail short	Fail intr-op	Fail long	Fist	Mediast	Emphys	Temp RLN	Perm RLN	Haemat	Steno	Death	Overl comp	Hosp stay (days)
Lerut et al. [5]	24	Cohort	0	0	0	0	3	0	0	3	0	0	0	0	6	15
Payne and King [6]	888	Cohort	32	0	0	32	16	0	0	0	28	11	0	11	66	5
Luckhaupt and Rose [7]	19	comp	0	0	0	0	0	0	0	2	0	0	1	0	3	NA
Weich and Stafford [8]	28	comp	3	3	0	0	2	0	0	2	0	0	0	0	4	NA
Bowdler and Stell [9]	21	comp	6	6	0	0	4	0	0	1	0	2	0	2	9	10
Konowitz and Biller [10]	20	comp	0	0	0	0	1	0	0	0	0	3	0	0	4	9
Westmore [11]	18	Cohort	0	0	0	0	0	0	0	0	0	0	0	0	0	6
Broll et al. [12]	15	Cohort	2	1	0	1	1	0	0	1	0	0	0	0	2	NA
Maurer et al. [13]	18	Cohort	0	0	0	0	2	0	0	0	0	2	1	0	5	12
Molins et al. [14]	16	Cohort	0	0	0	0	0	0	0	0	0	0	1	0	1	3.5
Morton and Bartley [15]	15	comp	1	0	0	1	2	0	0	0	1	3	0	0	6	9
Laccourreye et al. [16]	14	comp	0	0	0	0	2	1	0	0	0	3	1	0	7	15
Laing et al. [17]	67	Cohort	2	2	0	0	6	0	0	3	0	2	0	0	11	7
Lippert and Werner [18]	76	comp	1	0	0	1	1	3	0	8	0	0	2	0	14	NA
Witterick et al. [19]	18	Cohort	1	0	0	1	0	0	0	0	0	1	2	0	3	NA
Hecker and Junginger [20]	36	Cohort	1	0	0	1	4	0	0	1	0	2	1	0	8	14
Ochando Cerdan et al. [21]	15	comp	0	0	0	0	1	0	0	0	0	1	0	1	3	12
Crescenzo et al. [22]	61	comp	0	0	0	0	4	0	0	0	0	1	0	0	5	5
Fraczek et al. [23]	16	comp	0	0	0	0	2	0	0	1	0	0	0	0	3	NA
Feeley et al. [24]	24	Cohort	0	0	0	0	2	0	0	0	1	1	2	0	6	NA
Zbaren et al. [25]	66	comp	4	0	0	4	7	1	0	3	1	2	0	1	15	11.5
Leporrier et al. [26]	20	comp	0	0	0	0	0	0	0	0	0	0	0	0	0	8.5
Dennis and Mal [27]	30	Cohort	1	0	0	1	0	0	0	0	0	0	0	0	0	NA
Gutschow et al. [28]	46	comp	8	4	0	4	6	0	0	0	0	0	0	0	6	10.5
Colombo-Benkmann et al. [29]	79	comp	2	0	0	2	3	0	0	6	0	1	0	0	10	8.5
Jougon et al. [30]	69	Cohort	0	0	0	0	1	0	0	0	0	2	0	0	3	8
Chang et al. [31]	28	comp	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Wirth et al. [32]	28	comp	3	1	0	2	2	0	0	0	0	0	0	0	2	12.5
Bonavina et al. [33]	116	comp	9	2	0	7	2	0	0	1	0	1	0	1	5	8
Smejkal et al. [34]	30	Cohort	3	1	0	2	3	0	0	2	0	1	0	0	6	13
Brigand et al. [35]	18	comp	3	2	0	1	2	0	0	1	0	1	0	0	4	9
Simic et al. [36]	14	comp	3	2	0	1	0	0	0	5	0	0	0	0	0	NA

Table 1 continued

Reference	nr Patients	Study	Fail tot	Fail short	Fail op	Fail intr-op	Fail long	Fist	Mediast	Emphys	Temp RLN	Perm RLN	Haemat	Steno	Death	Overll comp	Hosp stay (days)
Mantsopoulos et al. [37]	37	Comp	1	0	0	0	1	2	0	2	5	0	3	0	0	12	11

*nr* number, *fail* failure, *tot* total, *short* short term, *intr-op* intra-operative, *long* long term, *fist* fistula, *mediast* mediastinitis, *emphys* emphysema, *RLN* recurrent laryngeal nerve, *temp* temporary, *perm* permanent, *haemat* haematoma, *steno* stenosis, *overll* overall, *comp* complications, *hosp stay* hospital stay, *NA* not addressed, *comp* comparative, *unpub* unpublished

external approaches. Diverticulectomy with or without cricopharyngeal myotomy comprised 33 studies (1,990 patients) and 22 studies (1,089 patients) reported on endoscopic stapler diverticulotomy.

#### Within-group differences

Comparing the different transcervical techniques, the rate of fistula and length of hospital stay (LOS) was significantly higher after excision of the pouch ( $p < 0.01$ , and  $p < 0.03$ , respectively) (Table 1). Fistula rate was 4 % for excision, compared to 1 % with inversion and suspension (Tables 2, 3). LOS after excision, inversion and suspension was 9.5, 6.2 and 5.4 days, respectively. Failure rate between different techniques was not significantly different despite apparent greater success with the suspension technique. Of the different transcervical techniques, suspension provided best overall outcomes (Fig. 2).

When comparing endoscopic diverticulotomy with stapler, laser or coagulation, the stapling technique has significantly lower rate of mediastinitis (0.2 %) and emphysema (0.8 %) ( $p < 0.01$ ) as well as shorter LOS ( $p < 0.03$ ) (Tables 4, 5, 6). LOS with stapler, laser and coagulation is 3.2, 5.2 and 4.5 days, respectively. Failed exposure accounted for 6.2 % with stapler and 6.4 % with laser. Coagulation has no reported problems with exposure, however, only four papers are included and the last report dates from 1997. Stapling provides the best overall outcomes from the different endoscopic techniques (Fig. 3).

#### Between-group differences

##### Primary outcome: failure

Rate of failure is significantly higher with endoscopic techniques ( $p < 0.001$ ); 18.4 % compared to 4.2 % for external approaches. The major difference lies in the short-term failure ( $p < 0.001$ , 14.5 vs. 1.3 %), especially due to problems with exposure (5.2 vs. 0 %) (Fig. 4).

##### Secondary outcomes: complications, length of stay

Complications yield a different pattern with the various surgical approaches (Fig. 5). Mediastinitis ( $p < 0.01$ , 1.2 vs. <0.3 %) and emphysema ( $p < 0.001$ , 3.0 vs. <0.1 %) occur significantly more often with endoscopic treatment. Fistula ( $p < 0.01$ , 3.7 vs. 1.2 %), recurrent nerve palsy ( $p < 0.001$ , 3.4 vs. <0.3 %), and haematoma ( $p < 0.01$ , 2.2 vs. <0.6 %) with transcervical treatment. Postoperative stenosis is uncommon and comparable between groups. Surgery-related deaths were infrequent in both groups (0.9 % for the open approach vs 0.4 % for endoscopic techniques). Overall postoperative complications tend to

**Table 2** Inversion

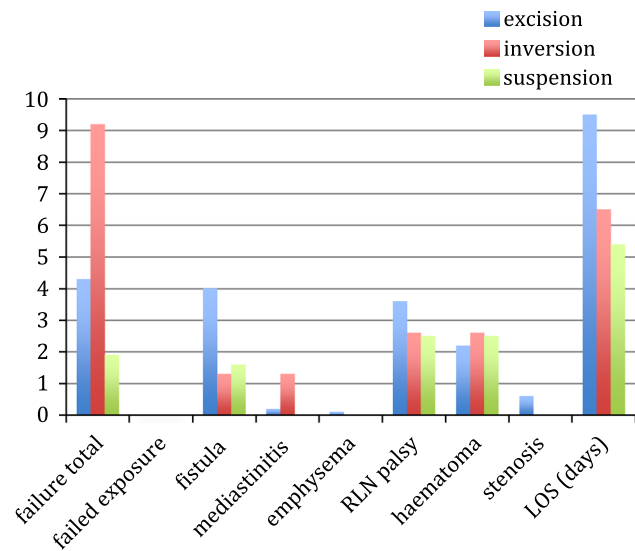
Reference	nr patients	Study	Fail tot	Fail short	Fail intr-op	Fail long	Fist	Mediast	Emphys	Temp RLN	Perm RLN	Haemat	Steno	Death	Overll comp	Hosp stay (days)
Luckhaupt and rose [7]	24	comp	4	0	0	4	0	1	0	0	0	0	0	2	3	NA
Bowdler and steil [9]	20	comp	3	3	0	0	1	0	0	1	0	2	0	0	4	6.5
Morton and Bartley [15]	18	comp	0	0	0	0	0	0	0	0	0	0	0	1	1	3
Mantsopoulos et al. [37]	14	comp	0	0	0	0	0	0	0	1	0	0	0	0	1	9

nr number, fail failure, tot total, short short term, intr-op intra-operative, long long term, fist fistula, mediast mediastinitis, emphys emphysema, RLN recurrent laryngeal nerve, temp temporary, perm permanent, haemat haematoma, steno stenosis, overall overall, comp complications, hosp stay hospital stay, NA not addressed, comp comparative, unpub unpublished

**Table 3** Suspension

Reference	nr Patients	Study	Fail tot	Fail short	Fail intr-op	Fail long	Fist	Mediast	Emphys	Temp RLN	Perm RLN	Haemat	Steno	Death	Overll comp	Hosp stay (days)
Konowitz and Biller [10]	12	comp	0	0	0	0	0	0	0	0	0	0	0	0	0	5
Lerut et al. [38]	94	Cohort	0	0	0	0	1	0	0	0	0	0	0	0	1	NA
Laccourrye et al. [16]	29	comp	0	0	0	0	1	0	0	1	0	5	0	1	8	7
Fraczek et al. [23]	21	comp	0	0	0	0	0	0	0	1	0	0	0	0	1	NA
Leporrier et al. [26]	19	comp	0	0	0	0	1	0	0	3	0	1	0	0	5	9.5
Gutschow et al. [28]	47	comp	0	0	0	0	2	0	0	0	0	0	0	1	3	2
Morse et al. [39]	14	comp	0	0	0	0	0	0	0	0	0	0	0	0	0	2.5
Brigand et al. [35]	18	comp	0	0	0	0	0	0	0	1	0	0	0	0	1	9
Simic et al. [36]	36	comp	5	4	0	1	0	0	0	2	0	0	0	0	0	NA
Vanclooster, unpub data	27	Cohort	1	1	0	0	0	0	0	0	0	2	0	0	2	3

nr number, fail failure, tot total, short short term, intr-op intra-operative, long long term, fist fistula, mediast mediastinitis, emphys emphysema, RLN recurrent laryngeal nerve, temp temporary, perm permanent, haemat haematoma, steno stenosis, overall overall, comp complications, hosp stay hospital stay, NA not addressed, comp comparative, unpub unpublished



**Fig. 2** Histogram of incidence for each of the outcomes under consideration, using an external surgical approach for Zenker's diverticulum. The y-axis refers to mean rate (%)

occur more frequently after transcervical approach (7 vs 11 %). LOS is significantly shorter after endoscopic treatment ( $p < 0.001$ , 3.9 vs 8.4 days) (Fig. 5).

#### Comparing “best” endoscopic and “best” transcervical techniques

Rate of failure is significantly higher with stapling than with sac suspension (18.9 vs 1.9 %,  $p < 0.001$ ). Complications for these techniques have a different pattern; however, there is no statistically significant difference in frequency. Reported mean LOS is significantly shorter after endoscopic stapling (3.2 vs 5.4 days,  $p < 0.03$ ) (Fig. 6).

#### Flexible endoscopic treatment

Eight studies report on flexible endoscopic treatment, which is performed under sedation (Table 7; Fig. 7). Different techniques are used: cap-assisted (three reports), needle knife papillotomies (three reports), argon laser (one report) and diverticuloscope (two reports). In two series, diverticulotomy is performed in multiple sessions over several days. Failure is 29 %. Most frequent reported complications are emphysema (8 %), fistula (5.6 %), haematoma (0.4 %) and mediastinitis (0.4 %). Mean length of stay is 3.6 days.

## Discussion

This literature review indicates a failure rate from endoscopic surgical techniques that is significantly higher than for transcervical procedures (18.4 vs 4.2 %), especially in

respect of short-term failure (14.5 vs 1.3 %). A particular issue relates to difficulty with access (5.2 vs 0 %). As expected, the pattern of complications differs widely with surgical approach.

Overall, postoperative complications tend to occur more frequently with the transcervical approach (7 vs 11 %). Any particular complication occurs less than 4 % of the time, but mediastinitis and emphysema occur significantly more often with endoscopic treatment whereas fistula, recurrent nerve palsy and haematoma are more likely with the transcervical, sac-excision approach. Length of stay is significantly shorter after endoscopic treatment.

Of the various endoscopic techniques, the stapling technique had significantly more problems with exposure and intra-operative failure—but significantly less mediastinitis and emphysema, and a shorter length of hospital stay—compared to laser or coagulation. On balance, the stapling technique can be considered to provide the best outcomes using an endoscopic approach.

Of the different transcervical techniques, excision of the pouch had a higher fistula rate and longer length of hospital stay compared with inversion or suspension. Overall, the suspension technique provided the best overall outcome among transcervical procedures, although the numbers for the inversion technique were too small for robust comparison.

The principles of treatment for Zenker's diverticulum are to obtain lower morbidity and fewer complications without compromising the functional outcome. The transcervical approach is technically more challenging as surgical dissection of the neck is required. Endoscopic treatment requires no open dissection which might explain its popularity with surgeons less experienced in head and neck surgery.

If one compares the “best” of the endoscopic and open approaches (i.e., diverticulopexy and stapling), the difference in complications is minimal because the risk of fistula after the “mucosa-preservation” open approach is very low.

Several publications confirm lower morbidity, shorter operation time and shorter length of stay with endoscopic treatment [3, 4, 31–33, 40–49]. Our results confirm these findings. But by avoiding resection of the pouch, LOS is much improved with inversion and suspension of the diverticulum. In our hands (using open approach and sac inversion), patients start on a soft oral diet the evening of—or the day after—surgery and can leave the hospital the first or second postoperative day.

Endoscopic stapling of Zenker's diverticulum is popular, presumably related to the simple surgical approach, low morbidity and fast recovery. However, a substantial proportion of patients cannot be treated because of intra-operative failure or unfavourable anatomical factors [4]

**Table 4** Stapler

Reference	nr Patients	Study	Fail tot	Fail short	Fail intr-op	Fail long	Fist	Mediast	Emphys	Temp RLN	Perm RLN	Haemat	Steno	Death	Overll comp	Hosp stay (days)
Baldwin and Toma [40]	52	Cohort	1	1	1	0	1	0	1	0	0	0	0	1	3	2
Name et al. [41]	102	Cohort	9	4	4	5	0	0	0	0	0	0	0	0	0	4
Luscher and Johansen [42]	23	Cohort	1	0	0	1	1	1	0	0	0	0	0	0	2	NA
Jaramillo et al. [43]	32	Cohort	12	7	5	5	0	0	0	0	0	0	0	0	0	3
Gutschow et al. [28]	31	comp	3	3	0	0	0	0	0	0	0	0	0	0	0	3
Raut and Primrose [44]	25	Cohort	11	11	2	0	2	0	0	0	0	0	0	0	2	3
Stoekli and Schmid [45]	30	Cohort	4	3	3	1	0	0	0	0	0	0	0	0	0	2
Chang et al. [46]	150	Cohort	29	21	9	8	1	0	0	1	0	0	0	0	2	1
Manni et al. [47]	24	cohort	5	5	3	0	0	0	0	0	0	0	0	0	0	2
Aly et al. [48]	31	Cohort	7	6	4	1	0	0	0	1	0	1	0	2	4	3.5
Casso et al. [49]	41	Cohort	12	5	1	7	6	1	5	0	1	0	0	0	13	3
Tsikoudas et al. [50]	21	Cohort	5	3	3	2	1	0	0	0	0	0	0	0	1	4
Wirth et al. [32]	24	comp	6	4	3	2	1	0	1	1	0	0	0	1	4	5.5
Bonavina et al. [33]	181	comp	31	16	8	15	0	0	0	0	0	0	0	0	0	3
Lang et al. [51]	31	Cohort	3	1	1	2	6	0	0	0	0	1	0	0	7	6
Morse et al. [39]	28	comp	4	4	4	0	0	0	0	0	0	0	1	0	1	2
Folia et al. [52]	30	Cohort	6	6	4	0	0	0	0	0	0	0	0	0	0	6
Lieder et al. [53]	62	Cohort	17	12	7	5	2	0	0	0	0	0	0	0	2	2
Rizzetto et al. [54]	51	comp	16	2	2	14	1	0	0	0	0	1	0	0	2	5
Wasserzug [55]	55	Cohort	9	9	4	0	1	0	1	0	0	0	0	0	2	2
Verhaegen et al. [56]	35	comp	10	9	0	1	0	0	1	0	0	0	0	0	1	2
Recipi et al. [57]	30	comp	5	3	0	2	1	0	0	0	0	0	0	0	1	3.5

nr number, fail failure, tot total, short short term, intr-op intra-operative, long long term, fist fistula, mediast mediastinitis, emphys emphysema, RLN recurrent laryngeal nerve, temp temporary, perm permanent, haemat haematoma, steno stenosis, overll overall, comp complications, hosp stay hospital stay, NA not addressed, comp comparative, unpub unpublished

**Table 5** Laser

Reference	nr Patients	Study	Fail tot	Fail short	Fail intr-op	Fail long	Fist	Mediast	Emphys	Temp RLN	Perm RLN	Haemat	Steno	Death	Overll comp	Hosp stay (days)
Flikweert and van der Baan [58]	36	Comp	5	5	0	0	0	1	4	0	0	0	0	2	7	NA
Kuhn and Bent [59]	10	Cohort	2	2	0	0	0	0	1	0	0	0	0	0	1	5
van Overbeek [60]	216	Comp	34	34	0	0	0	5	7	0	0	1	0	0	13	NA
Bradwell et al. [61]	15	Cohort	4	2	0	2	1	0	1	0	0	1	0	0	3	5
Flamenbaum et al. [62]	17	Cohort	1	1	0	0	1	0	1	0	0	0	0	0	2	5
Gehanno et al. [63]	59	Cohort	11	9	0	2	0	1	0	0	0	0	0	0	1	NA
Zbaren et al. [25]	31	Comp	5	5	1	0	0	0	2	0	0	1	0	0	3	8
Gutschow et al. [28]	55	Comp	14	14	0	0	0	2	2	1	0	0	0	0	5	5
Krespi et al. [64]	83	Cohort	12	6	0	6	2	0	1	0	0	2	0	0	5	2
Hoffmann et al. [65]	119	Cohort	4	0	0	4	0	2	0	0	0	0	0	1	3	4.5
Chang et al. [31]	26	Comp	7	4	2	3	0	0	0	0	0	0	0	0	0	4
Verhaegen et al. [56]	72	Comp	29	24	0	5	0	0	20	0	0	1	0	1	22	5
Koch et al. [66]	155	Comp	66	66	54	0	0	2	1	2	0	1	0	0	6	9

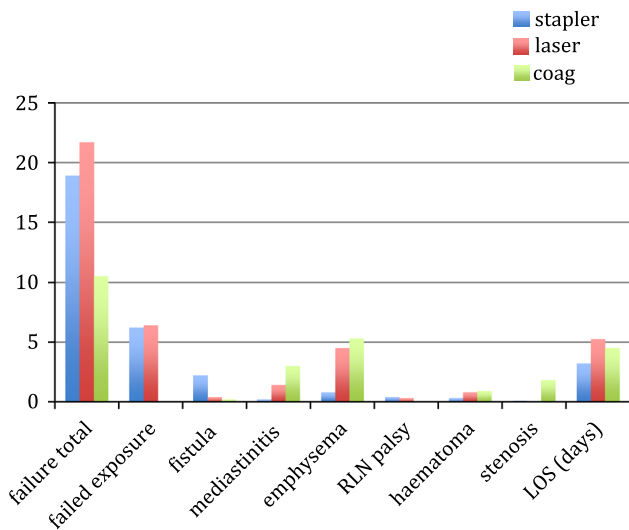
nr number, fail failure, tot total, short short term, intr-op intra-operative, long long term, fist fistula, mediast mediastinitis, emphys emphysema, RLN recurrent laryngeal nerve, temp temporary, perm permanent, haemat haematoma, steno stenosis, overall overall, comp complications, hosp stay hospital stay, NA not addressed, comp comparative, unpub unpublished

**Table 6** Coagulation

Reference	nr Patients	Study	Fail tot	Fail short	Fail intr-op	Fail long	Fist	Mediast	Emphys	Temp RLN	Perm RLN	Haemat	Steno	Death	Overll comp	Hosp stay (days)
Welch and stafford [8]	32	comp	13	13	0	0	0	2	3	0	0	0	0	1	6	NA
Flikweert and van der Baan [58]	37	comp	13	12	0	1	0	3	6	0	0	0	0	0	9	NA
van Overbeek [60]	328	comp	17	17	0	0	1	7	10	0	0	4	8	1	31	NA
von Doersten [67]	40	Cohort	3	3	0	0	0	1	4	0	0	0	0	0	5	4.5

nr number, fail failure, tot total, short short term, intr-op intra-operative, long long term, fist fistula, mediast mediastinitis, emphys emphysema, RLN recurrent laryngeal nerve, temp temporary, perm permanent, haemat haematoma, steno stenosis, overall overall, comp complications, hosp stay hospital stay, NA not addressed, comp comparative, unpub unpublished





**Fig. 3** Histogram of incidence for each of the outcomes under consideration, using an endoscopic surgical approach for Zenker’s diverticulum. The y-axis refers to mean rate (%)

and there is a higher recurrence rate and higher rate of persistent symptoms [75].

Bloom et al. [76] reported failure of exposure in 30 % of endoscopic stapling cases. The major contributing factors were shorter neck, shorter hyomental distance and higher BMI. Prominent dentition was not significantly related to difficult exposure, but there was evidence of a trend toward an association. Koch et al. [66] compared laser-assisted diverticulotomy to open approach and reported conversion to open approach in 30.8 % mainly because of pouch-related problems, but also because of prominent teeth and insufficient neck motility. Moreover, an endoscopic approach was not attempted in 5.8 % of patients because of preoperatively unfavourable anatomy. Thus, in their group 38.7 % of patients could be addressed only by open approach [66]. Also size matters; Rizzetto et al. [54] reported a 36 % chance of recurrence after stapling diverticulotomy in patients with small diverticula  $\leq 3$  cm. In our review, intra-operative problems accounted for up to 6.2 % of failures in the endoscopic stapling group, which is comparable to the findings of Leong [4]. Patient selection regarding pouch size and anatomical conditions will help the surgeon in his preoperative assessment to choose the most suitable approach for each individual case.

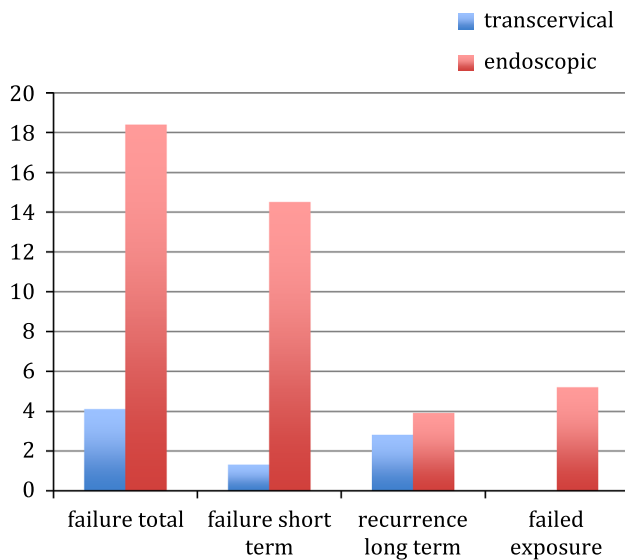
Recurrence after endoscopic treatment is significantly higher (18.4 % compared to 4.2 %), especially comparing stapling with open suspension (18.9 vs 1.9 %). Most authors state that reoperation is as straightforward with comparable low complication and morbidity rate as the initial surgery. After endoscopic treatment, the remaining cricopharyngeal bar is often clearly apparent on postoperative radiographs [19, 77]. Jaramillo et al. [43] reported

**Table 7** Flexible approach

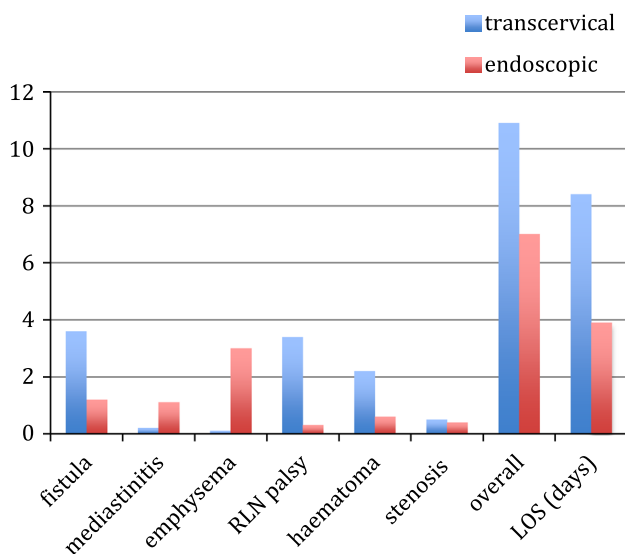
Reference	nr Patients	Study	Fail tot	Fail short	Fail short	Fail intr-op	Fail long	Fist	Mediast	Emphys	Temp RLN	Perm RLN	Haemat	Steno	Death	Overll comp	Hosp stay (days)
Ishioka et al. [68]	42	Cohort	6	3	0	0	3	0	0	1	0	0	0	0	0	1	NA
Evrard et al. [69]	30	Cohort	3	2	0	1	1	1	1	1	0	0	0	0	0	3	2
Rabenstein et al. [70]	41	Cohort	16	13	0	3	1	0	1	1	0	0	0	0	0	2	8
Costamagna et al. [71]	28	Comp	20	16	0	4	5	0	2	0	0	0	0	0	0	7	3
Costamagna et al. [71]	11	Comp	2	1	0	1	0	0	0	0	0	0	0	0	0	0	3
Vogelsang et al. [72]	31	Cohort	15	10	0	5	0	0	7	0	0	0	0	0	0	7	5
Al-Kadi et al. [73]	18	Cohort	2	2	0	0	1	0	1	0	0	0	0	0	0	2	2
Case and Baron [74]	22	Cohort	7	0	0	7	6	0	6	0	0	0	1	0	0	13	3
Recipi et al. [57]	28	comp	3	2	0	1	0	0	1	0	0	0	0	0	0	1	2.5

Costamagna et al. [71] used 2 different flexible techniques; 28 cap assisted and 11 with diverticuloscope

nr number, fail failure, tot total, short short term, intr-op intra-operative, long long term, fist fistula, mediast mediastinitis, emphys emphysema, RLN recurrent laryngeal nerve, temp temporary, perm permanent, hemat haematoma, steno stenosis, overll overall, comp complications, hosp stay hospital stay, NA not addressed, comp comparative, unpub unpublished

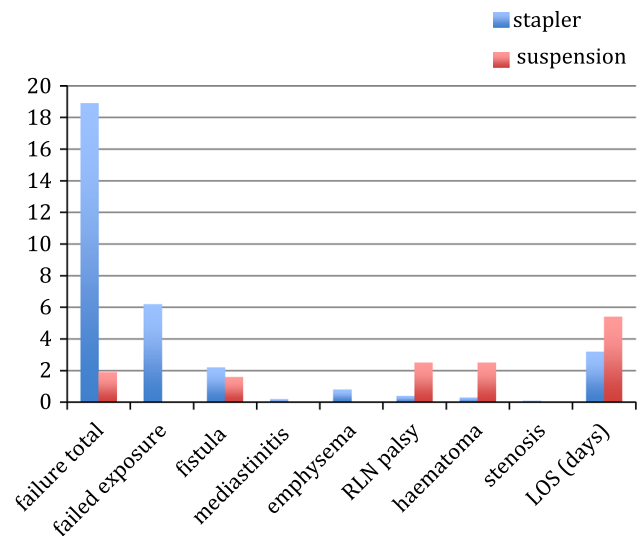


**Fig. 4** Histogram of incidence for the primary outcome, comparing external and endoscopic surgical approaches for Zenker's diverticulum. The y-axis refers to mean rate (%)

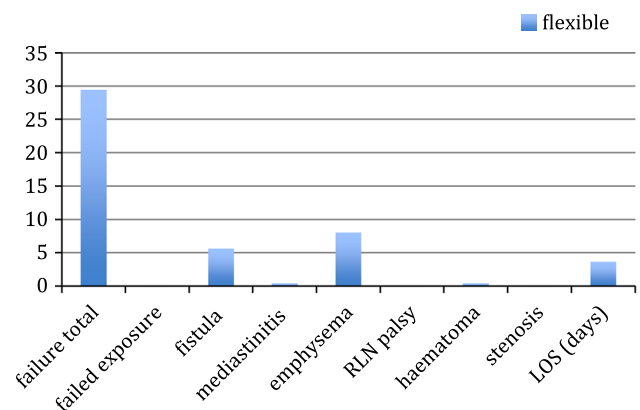


**Fig. 5** Histogram of incidence for secondary outcomes, comparing external and endoscopic surgical approaches for Zenker's diverticulum. The y-axis refers to mean rate (%)

persisting pouches on postoperative barium swallow in all treated patients; 66 % of cases actually showed no difference compared to preoperative radiographs. Though it is claimed that there is no clear correlation between radiological findings and postoperative symptoms [19, 43, 77], a persisting bar is present and several authors advocate the importance of complete myotomy of the cricopharyngeal muscle for at least 4–5 cm [6, 10, 16, 19, 28, 30, 37, 38]. An external approach allows better control for a complete



**Fig. 6** Histogram of incidence for outcomes with the “best” external and “best” endoscopic surgical approaches for Zenker's diverticulum. The y-axis refers to mean rate (%)



**Fig. 7** Histogram of incidence for outcomes using a flexible endoscopic surgical approach for Zenker's diverticulum. The y-axis refers to mean rate (%)

myotomy. We believe that incomplete transection of the cricopharyngeal muscle plays an important role in persistent and recurrent symptoms after endoscopic treatment.

Most papers, do not grade the postoperative patient-based outcomes. Wirth et al. [32] reported in 2006 good postoperative satisfaction, quality of life and relief of symptoms no matter whether after open or endoscopic treatment. They used a qualified, standardised and well-accepted questionnaire. Because of small numbers in both groups, it was not appropriate to compare satisfaction outcomes. However, persisting abnormalities on barium swallow and higher recurrence rate might mean that the subjective satisfaction after endoscopic treatment is less than with an open approach. Seth et al. [75] compared long-term outcomes of

endoscopic stapling treatment and transcervical external approach. They conducted a telephone survey. There was a high satisfaction postoperatively in both groups. However, complete resolution of symptoms was obtained more often after transcervical approach, and the endoscopic group had a worsening symptom profile over time compared with the transcervical group. The same recurrence of symptoms over time was reported by Chang et al. [46] in nearly 30 % of patients. Seth et al. [75] stated that patients treated by an open approach attain a greater resolution of symptoms than with endoscopic treatment and that endoscopic results tend to decline over time. Therefore, they advised that an open approach may be better suited for patients of younger age and with less medical comorbidities who would prefer a greater assurance of long-term resolution of symptoms [75].

Finally, a relatively new technique—the flexible endoscopic approach—developed and performed by gastroenterologists has a high complication and failure rate compared to both conventional endoscopic and open surgical treatments. More experience with this technique, and longer follow-up, is required. Nevertheless, this approach can be performed under sedation so it is suitable for patients who do not tolerate general anaesthesia.

## Conclusion

In general, open approaches have more success but more complications than endoscopic techniques. On balance, open and endoscopic approaches yield different patterns. For younger patients with few comorbidities and long-lasting expectations, as well as for patients with unfavourable anatomic conditions for endoscopic exposure, an open approach is preferred. Flexible endoscopic techniques under sedation provide a suitable option for patients with high comorbidity that do not tolerate general anaesthesia. Patient selection regarding pouch size and anatomical conditions will help the surgeon in his preoperative assessment to choose the most suitable approach for each individual case.

Significantly, all patients can be managed by an open mucosa-sparing approach, whereas only a proportion of patients can be successfully treated by endoscopic means. This review has prompted us to audit our own experience with sac inversion, as there is a relative paucity of information on that technique in the literature.

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