Retrospective and Prospective Study of Singapore Swing Method on Healing of Mastoid Cavity

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Abstract Chronic suppurative otitis media with cholesteatoma is a common problem. The majority of ENT surgeons find the canal wall down operation to be the safest and simplest means of treating cholesteatoma. The ‘Singapore Swing’ is a method of promoting healing of mastoid cavity. In this study our main objective was to do Singapore Swing technique in larger number of cases, have long term follow-up and to compare its results with other mastoid operations in which obliteration has not been used. Patients of cholesteatoma were divided into case group and control group. The case group (26 patients) was operated by canal wall down procedure with Singapore Swing obliteration while the control group (62 patients) was operated by same method without any obliteration. Both retrospective and prospective studies were done. Time period of drying of mastoid cavity, numbers of visits to the hospital and hearing status were observed. Subjective satisfaction score of patient (0–10) and Surgeon’s satisfaction score (fully satisfied, partially satisfied and not satisfied at all) were measured in both the groups. The time of drying of cavity was <2 months in 88.5% of cases, while 27.5% of controls. Mean time of drying of cavity was 46 days (1½ months) in case group, while it was 89 days (3 months) in control group. Gain in air conduction was 11–30 dB in 33.3% cases and 15.7% of controls. 2 patients

in control group had deterioration of 1–10 dB in air conduction. Subjective satisfaction score was 8–10 in 42.4% patients in case group, while 25% in control group. Surgeon was fully satisfied in 73% patients of case group and 45% patients of control group. The study suggested that Singapore Swing technique provides a dry, small and stable cavity with better hearing in less time.

Keywords Chronic suppurative otitis media · Cholesteatoma · Singapore Swing

Introduction

Chronic suppurative otitis media (CSOM) is a long standing infection of a part or whole of the middle ear cleft characterized by ear discharge and a permanent perforation. It is a fairly prevalent disease in this part of the country with symptoms of recurrent ear discharge and diminished hearing.

Chronic suppurative otitis media is divided into two groups, tubotympanic and atticoantral disease. Tubotympanic disease is characterized by a perforation of pars tensa. Generally this disease is not complicated and is called safe type of disease. Atticoantral disease commonly involves pars flaccida and is characterized by the formation of cholesteatoma. This type of disease is generally considered to be at risk of developing intracranial or extra cranial complications and is called unsafe type [1]. Open mastoidectomy technique has a long distinguished history and has been the mainstay of the management of such cases for the past one and a half century. The majority of general ENT surgeons find the canal wall down, open cavity operation with wide access to the middle ear to be the safest and simplest means of managing middle ear

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cholesteatoma. Problems with an open cavity are recurrent and foul smelling discharge in 20–30% patients, hearing impairment of about 40 dB, frequent visit to the hospital for removing wax and keratin to prevent infection and vertiginous episodes due to cold air or when swimming. To tide over these problems, otologists have devised mastoid obliteration techniques with many surgical options.

Obliteration of the mastoid cavity leaves a smaller surface requiring epithelialization and healing will thus be quicker, with a reduced likelihood of developing cavity granulation. The cavity, being smaller, is also more likely to retain its epithelial migratory potential and be self cleaning. Exposed bone following mastoidectomy will leak tissue fluid, which is a rich medium for bacterial proliferation. When the bony walls are covered, this process of transudation is reduced, with an attendant reduction in the risk of infection. The smaller surface area and the protection of the lateral canal by new bone and self tissue allow most patients to swim free of complications. Hearing aids, if required, are better tolerated in an obliterated cavity than an open cavity. It is undesirable to fit hearing aid in a discharging cavity and constructing a mould to either an enlarged or stenotic meatus is seldom satisfactory.

Various methods to obliterate the cavity has been devised like muscle pedicled flaps, obliteration with bone, cartilage, biocompatible materials and fat.

Gibb et al. [2] used an inferiorly based rotation graft to cover the mastoid cavity, which he entitled 'The Singapore Swing'. The Singapore Swing is a composite flap, shaped like a boomerang, comprising temporalis fascia superiorly and the periosteum of the outer mastoid cortex inferiorly. The pedicle is sited inferiorly near the mastoid tip and is based on a branch of the postauricular artery. The flap can be readily rotated and swung forward into the operation area and is large enough both to line the entire mastoid cavity and repair the tympanic membrane. The periosteal segment of the Singapore Swing derives its blood supply from a branch of the postauricular artery which crosses the anterior edge of the mastoid tip and passes upwards and backwards over the surface of the mastoid stopping short of the temporalis fascia. The main vessel supplying the temporal area is the superficial temporal artery, the main branches of which pass to the layer of loose connective tissue lying superficial to the temporalis fascia which is normally discarded when taking a fascial graft. However, one or two small vessels could be identified entering the true fascia on its deep surface near its antero-inferior extremity. There was no evidence of vascular continuity between the fascial and periosteal components of the Singapore Swing but it was recognized that a micro-anastomosis might exist without showing up on the dye studies.

A review of the first 14 operations showed complete healing with dry ears and intact tympanic membranes in all

instances, three cases requiring secondary grafting of residual perforations. The quality of epithelium in the mastoid cavities after final healing was excellent and the chances of subsequent breakdown appeared minimal. He has used this technique in a small number of patients and there was no any control group. Their follow up was also for short duration. Hence, this study was planned to see its effect in large number of patients for a longer duration of time.

Materials and Methods

This study was conducted on patients of CSOM having unsafe type of disease. Informed and written consent of the patients regarding participation in the study was taken.

Criteria for Selection of Patients

Exclusion Criteria

1. Children <12 years of age.
2. Known cases with intracranial complications.
3. During mastoidectomy if we found that the sinus plate or dural plate or the bone covering the Trautmann's triangle were eroded and covered with granulations or there was an extradural abscess in these areas.

Inclusion Criteria

1. All other cases of cholesteatoma where we were sure of complete extirpation of disease.

Patients, fulfilling inclusion and exclusion criteria, were divided into two groups either case group or control group.

1. Cases comprise of patients of cholesteatoma in which open mastoid technique combined with the Singapore Swing was done.
2. Control group comprise of patients of cholesteatoma in which open mastoid operation was done without any obliteration.
3. Prospective and retrospective cases were included where we could get complete hospital records. Prospective cases were randomised by chit draw system.

Surgical Technique

The Singapore Swing was used in conjunction with a postauricular modified radical or radical mastoid operation. An extended approach, carrying the standard postauricular skin incision vertically upwards for 2.5 cm was employed to provide wide exposure of the mastoid and temporalis

fascia. A large tongue-shaped fascial flap based inferiorly was then incised and elevated from above downwards as far as the attachment of the fascia along the lower border of the temporalis muscle (Fig. 1).

At this point sharp dissection was done to release the flap on its deep surface so that further elevation could be continued sub-periosteally down to the mastoid tip (Fig. 2). The periosteal segment of the flap was kept as broad as possible as it was required to line much of the mastoid cavity. The pedicle of the flap, which should be at least 2 cm in breadth, was sited over the mastoid tip and contained the main feeder vessel from the postauricular artery, which was carefully identified and preserved.

The flap was protected in a moist swab during the subsequent mastoidectomy procedure. An adequate meatoplasty was then carried out.

Finally, the Singapore Swing was spread out to cover the entire mastoid cavity leaving no areas of exposed bone, while the free fascial extremity of the flap was inserted as an underlay graft to repair the tympanic membrane (Fig. 3). Ossiculoplasty, if required, was done as a single

Fig. 1 Elevation of the Singapore Swing

Fig. 2 Coronal representation of Singapore Swing after elevation

Fig. 3 Flap 'swung' into final position

stage procedure. The area of the tympanoplasty was protected with a thin layer of Gelfoam. A gauze pack impregnated with bismuth iodoform paraffin paste (BIPP) was used to fill the cavity. The packing was left undisturbed for at least 2 weeks. Systemic antibiotics were given for 15 days.

Follow up was done at 15 days, 1 month, 2 months, 3 months, 6 months, 1 year, 2 years, 3 years and 5 years. 2% Gentian violet was applied in the cavity till its healing.

Outcome measures were time of drying of the mastoid cavity, number of visits to the hospital after surgery, hearing status (measured on the basis of post operative gain of air conduction in pure tone audiometry), subjective satisfaction score (0–10, where 0—not satisfied at all and 10—fully satisfied) and surgeon's satisfaction score. Surgeon's satisfaction score was based on ear discharge, deafness, vertigo, tinnitus and otalgia, whether present or absent. Based on these 5 criterias, we categorized our patients in categories- fully satisfied, partially satisfied or not satisfied at all.

Results

The study was conducted from Oct 2008 to Sept 2009. A total of 26 cases (eight prospective and 18 retrospective) and 62 controls (11 prospective and 51 retrospective) were included. Retrospective type of study was done on follow-up cases during the time period of 2002–2008. 35 patients with various complications operated during this period have been excluded from the study.

In the present study most of the patients were in age group 12–20 years comprising about 59.0% ($n = 52$) of the patients. Male to female ratio was 64:36 (1: 0.625 in case group and 1: 0.550 in control group). 100% patients were having cholesteatoma in both case and control group.

Most of the patients were having attic perforation (42.3% of cases and 41.9% of controls), postero-superior retraction (38.4% of cases and 29.0% of controls) or both (19.2% of cases and 19.4% of controls). In most of the cases cholesteatoma was present in attic, aditus and antrum per-operatively (Table 1).

Depending upon the extent, modified radical mastoidectomy was done in 77.0% ($n = 20$) of cases and 66.1% ($n = 41$) of controls. In 15.3% ($n = 4$) of cases and 8.1% ($n = 5$) of controls atticoantrostomy was done. In 7.7% ($n = 2$) of cases and 25.8% ($n = 16$) of controls radical mastoidectomy was done (Table 2). The time of follow up in prospective cases was 1 year and we had 100% dry ears in case group and 62.5% dry ears in control group. In case group 88.5% of patients had dry cavity in <2 months duration, while in control group only 27.5% of patients had dry cavity in <2 months time duration (Table 3).

Table 1 Pathology

Pathology	Case ($n = 26$)		Control ($n = 62$)	
	Number	% age	Number	% age
Attic perforation alone	11	42.3	26	41.9
Posterosuperior retraction alone	10	38.4	18	29.0
Attic perforation + posterosuperior retraction	5	19.2	12	19.4
Granulation with attic perforation	1	3.8	9	14.5

Table 2 Type of operation

Type of operation	Cases ($n = 26$)		Controls ($n = 62$)	
	Number	% age	Number	% age
Atticoantrostomy	4	15.3	5	8.1
Radical mastoidectomy	2	7.7	16	25.8
Modified radical mastoidectomy	20	77.0	41	66.1

Table 3 Time of drying of cavity

Time period	Cases		Controls	
	Number	% age	Number	% age
15 days	2	7.6	0	0.0
1 month	9	34.6	1	2.5
1½ months	3	11.5	3	7.5
2 months	9	34.6	7	17.5
2½ months	3	11.5	6	15.0
3 months	0	0.0	8	20.0
	26		40	

Mean time period of drying of cavity was 46 days (1½ months) in case group, while it was 89 days (3 months) in control group. The comparison between the time of drying of cavity of case group and control group was found to be statistically significant ($P < 0.05$). This shows that there was definite and statistically significant decrease in time of drying of cavity in case group as compared to control group. In our study, in 34 patients post operative audiometry was done and there was a gain of 21–30 dB in 13.3% of cases and a gain of 11–20 dB in 20.0% of cases, while in control group only 15.7% of controls had gain of 11–20 dB and no control had a gain of >20 dB (Table 4). There was a deterioration of hearing of 1–10 dB in 2 patients of control group in present study. Therefore, we can say that Singapore swing technique seems to be better than control for improvement in hearing.

A total of 66 patients were asked about subjective satisfaction score. In case group 42.4% patients had subjective satisfaction score of 8–10, while in control group only 25.0% patients had subjective satisfaction score of 8–10 (Table 5). The difference was statistically significant ($P < 0.05$). Hence, more number of patients was satisfied by Singapore swing as compared to control group.

In our study, the surgeon was fully satisfied in 73% patients of case group and only 45% patients of control group (Table 6). There was statistically significant difference between surgeon's satisfaction score ($P < 0.05$) in favour of case group. From this, we can say that surgeon is more satisfied with Singapore swing technique than controls.

In our study, there was no immediate postoperative complication. 2 cases (7.6%) from retrospective study had

Table 4 Hearing status

Gain of air conduction	Cases		Controls	
	Number ($n = 15$)	% age	Number ($n = 19$)	% age
No gain	1	6.67	1	5.2
<10 dB	9	60.0	15	78.9
11–20 dB	3	20.0	3	15.7
21–30 dB	2	13.3	0	0.0

Table 5 Subjective satisfaction score

Score (0–10)	Cases		Controls	
	Number ($n = 26$)	% age	Number ($n = 40$)	% age
<5	0	0.0	8	20.0
6–7	15	57.6	22	55.0
8–10	11	42.4	10	25.0

Table 6 Surgeon's satisfaction score

Category	Cases		Controls	
	Number	% age	Number	% age
Fully satisfied	19	73.0	16	45.0
Partially satisfied	6	23.0	18	40.0
Not satisfied at all	1	4.0	6	15.0
	26		40	

intermittent otorrhea, out of which one had a very small pars tensa perforation and the other had scanty discharge due to raw area in anterosuperior quadrant of epitympanum. Both of these cases were managed conservatively. No case from the prospective study had otorrhea in the follow up.

22 patients of the control group (35.4%) had intermittent otorrhea. 1 patient of control group (1.6%) suffered from perichondritis and required hospitalization. Till date we have found no evidence of recurrence of cholesteatoma in case group.

Discussion

The global burden of illness from CSOM involves 65–330 million individuals with draining ears, 60% of whom (39–200 million) suffer from significant hearing impairment. Over 90% of the burden is borne by countries in the South-east Asia and Western Pacific regions, Africa, and several ethnic minorities in the Pacific Rim. CSOM is uncommon in the Americas, Europe, the Middle East, and Australia. Among the South-East Asian countries, prevalence rate of CSOM in Thailand ranged from 0.9 to 4.7% while the Indian prevalence is 7.8% [3].

The goals of surgery in CSOM are to create a dry, safe ear and preserve or restore hearing as much as possible. The type of mastoidectomy is based on the extent of the disease, preoperative health of the patient, the status of the opposite ear, and both the surgeon's and patient's preference.

The canal wall up mastoidectomy involves removing the mastoid air cells lateral to the facial nerve and otic capsule bone while preserving the posterior and superior external auditory canal walls. It preserves the normal anatomy of the ear canal, thus avoiding the risk of bowl problems and the necessity for periodic cleaning and leading to reduced healing time and, possibly, better hearing results [4]. However, a high residual and recurrence rate continue to be major drawbacks to canal wall up surgery. Second stage surgery is frequently recommended 9–12 months after the initial surgery [5–7]. Glasscock [8] reported a recurrence

rate of 14%. Recurrence rates up to 20–40% have also been reported [5, 6]. Nyrop and Bonding's [9] 10 year follow up of canal wall up cases in Copenhagen showed that 70% required a later canal wall down surgery.

The canal wall down technique creates an open cavity after removal of the bony posterior canal wall, providing excellent exposure for cholesteatoma removal. Recurrence rate is lowered up to 5–10% [10, 11]. The main disadvantages of technique are related to the necessity for periodic cleaning of the mastoid cavity with persistent otorrhea. Other problems with open cavity include difficulty with the use of a hearing aid, water intolerance due to susceptibility to infection, and propensity to vertigo by a caloric stimulus such as warm/cold air or water [12]. These problems can be minimized by different oblitative procedures. Since the introduction of oblitative procedure by Mosher [13] with pedicled flap, various oblitative technique by different otologists have been tried using different 'biogenic' as well as alloplastic materials, with variable results. Kisch [14] reviewed this idea and used the temporalis muscle which he pedicled anteriorly. Popper [15] used the same muscle but with the inclusion of periosteum.

Hartwein et al. [16] described the use of hydroxyapatite to obliterate the mastoid bowl while reconstructing the posterior canal wall with autologous conchal cartilage. Yung [17] used hydroxyapatite with an inferiorly based periosteal flap. Mahendran and Yung [18] described the use of hydroxyapatite cement for mastoid obliteration.

Pedicled fascial grafts, however, proved much more successful, presumably on account of their better blood supply. Van Hasselt in 1994 lined the operation cavity with a pedicled graft of temporalis fascia. In a study the Hong Kong flap was used to reconstruct 107 cavities, 103 (96%) healed soundly. Minor complications occurred in 8 (7%) patients. 84 (78%) required no second exploratory operation [19, 20]. Drawbacks of this study were that there was no comment regarding the time of drying of cavity and hearing results after the surgery as well as this was a short term study.

Another retrospective study was done on 302 ears that had the Hong Kong procedure from 1987 to 2006 to study the long term results and complications. The main otologic complaint leading to use of the Hong Kong flap was otorrhea. It takes a median of 2 months to achieve a dry ear after the procedure [21]. In this study, there was no conclusion regarding the postoperative hearing status of the patient.

Gibb et al. [2] used an inferiorly based rotation graft to cover the mastoid cavity, which he entitled 'The Singapore Swing'. Healing was straightforward in 11 ears resulting in a dry cavity and intact tympanic membrane. In the other three cases, tympanic membrane defects were encountered post-operatively, all of which were successfully closed by

grafting. Thus all 14 ears were dry and soundly healed at the time of review. The problem with this study was that it was a very small series and there were no controls. In this series hearing status and time of drying of cavity were not studied. Their follow up was also for short duration. Present study was planned to remove all these shortcomings. We included prospective as well as retrospective cases to see immediate and long term results respectively. However, in our study also number of cases is limited as there were strict inclusion and exclusion criteria for cases and in our part of country patients seek treatment at a later stage when one or the other complication have already set in. 35 patients with various complications operated during this period have been excluded from the study.

In our study we have excluded the children below 12 years, as the pediatric cholesteatoma is known to be more aggressive with high residual and recurrent rate requiring revision surgeries. In the present series, the male to female ratio was 64:36 (1: 0.625 in case group and 1: 0.550 in control group). The increased number of male member seeking treatment in this series may be due to the fact that in our society the boy gets more attention than the girls, as they are groomed from their childhood to be the earning member of the family and much depends on their well being.

In the present study we have described the details of extent of cholesteatoma and type of surgery, which has not been done in previous studies.

In our study average time of follow up in prospective cases was 1 year and we had 100% dry ears in case group. Time of drying of mastoid cavity was <2 months in 88.5% patients of case group and 27.5% patients of control group. The difference between the time of drying of cavity of case group and control group (Table 3) was found to be statistically significant ($P < 0.05$) and was shorter in case group (46 days). Gibb et al. [2] had not mentioned about time of drying of cavity. Hung et al. [21], in his study of Hong Kong flap had noticed a median of 2 months time to achieve dry ear.

We have used a new scoring system to evaluate patient's and surgeon's satisfaction. Satisfaction scoring system has not been used in any of the previous studies.

In our study, there was no immediate postoperative complication. 2 cases (7.6%) from retrospective study had intermittent otorrhea, out of which one had a very small pars tensa perforation and the other had scanty discharge due to raw area in anterosuperior quadrant of epitympanum. Both of these cases were managed conservatively. No case from the prospective study had otorrhea in the follow up. 22 control (35.4%) had intermittent otorrhea. 1 patient of control group (1.6%) suffered from perichondritis and required hospitalization. Various complications have been noticed with cavity obliteration by different techniques.

Fritz and Crawford reported in 1960 the occurrence of brain abscess and death following musculopathy and primary closure in the cavity where a dural granuloma was present at the time of surgery [22]. Post operative hematoma and granulation tissue formation was noticed by Peck in several cases in 1961 [23]. Merifield [24] noticed recurrence of cholesteatoma and small abscess buried behind an oedematous soft tissue pedicle. After Hong Kong flap obliteration, 40% of the mastoid cavities were found to have residual or recurrent cholesteatoma [21]. Till date we have found no evidence of recurrence of cholesteatoma in case group. Our study had some shortcomings like number of cases was limited.

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