



COMPARATIVE ANALYSIS OF FUNCTIONAL OUTCOMES OF CANALPLASTY IN EAR SURGERIES

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ABSTRACT

Canalplasty is a procedure used to repair defects of the external auditory canal or intractably infected muco-cutaneous tissue in the canal and enlargement or straightening of a stenotic or tortuous external auditory canal. This study aimed to assess the role of canalplasty in ear surgeries like tympanoplasty, stapedotomy and exploratory tympanotomy in terms of intra operative ease, complete visualization of TM, graft take up rates, hearing improvement and complications. The comparative study was completed both through pro-active treatment/observation of patients admitted to the department. Various tools used in our study for measurements of outcomes (before and after surgery). In our study comparative analysis of functional outcomes of canalplasty in ear surgeries were done. In all a total of 100 cases were taken up for study but results are based upon outcomes of 80 patients only as 20 cases did not turn up for follow up. Final outcome of our study is that the hearing improvement and take up rate of graft in the cases of canalplasty is found to be significantly and statistically better than the cases done without canalplasty. This can be attributed to better visualization in placing the graft, preventing lateralization of the graft. It promote hearing improvement and healing.

INTRODUCTION

Ear related problems have a high order of magnitude in India accounting for about 7% of the population which ultimately leads to deafness. Of these, nearly 90% of patients have middle ear infections which in few cases lead to life threatening complications. Typical cases include chronic suppurative otitis media (CSOM) and otosclerosis; which become more complicated by exostoses and stenosis of the external auditory canal. An essential requisite for successful ear surgery is a patent external ear. A number of anatomic variants or abnormalities may obstruct its lumen, resulting in conductive hearing loss, hampering access for routine ear cleansing, or obscuring underlying pathology. Canalplasty can be done to successfully treat either bone or soft tissue blockages of the external auditory canal (Parisier SC *et al* 1999).

Canalplasty is the surgical procedure whereby the external auditory meatus is widened. The indications include exostoses, stenosing external otitis and widening for surgical access (Lavy J *et al* 2001). Canalplasty is usually done in conjunction with the procedures employed for correction or eradication of primary disease in middle ear. It can also be done as a primary procedure in cases of anterior bony overhang or exostoses. Canalplasty is done as a supplementary procedure in tympanoplasty or stapes surgery, whenever the view of entire tympanic membrane and annulus is obscured by bony deformities of the canal wall. In canalplasty external bony canal is enlarged with cutting and diamond burrs, eliminating

all bony overhangs particularly anterior and inferior. The overhanging canal bone is removed in steps to provide for elevation of the meatal skin before drilling. After a complete canalplasty, the entire tympanic annulus must be visible from one position of the microscope. After canalplasty, the shape of external canal corresponds to that of an inverted truncated cone with an outer diameter that is nearly twice that of tympanic membrane.

Many authors described canalplasty technique for the surgical treatment of chronic otitis media (Banerjee AR *et al* 1995; Peng B *et al* 1995; Zhang Z *et al* 2007). Canalplasty to prevent accumulation of squamous debris has been proposed as an adjunct or alternative to tympanoplasty for the treatment of tympanic membrane atelectasis and early cholesteatoma (Garside JA *et al* 1998). Canal stenosis and atresia can result from a number of causes, including congenital, inflammatory, neoplastic and iatrogenic pathologic conditions. Canalplasty is an eclectic collection of techniques designed to recreate a patent and trouble-free external canal (Parisier SC *et al* 1995).

Despite the large number of etiologies of acquired external auditory canal atresia (AEACA), the principles of canalplasty are the same. The goal of the canalplasty is creation of a widely patent and physiologically intact canal wall (Selesnick S *et al* 1995). Both the bony and cartilaginous portions must be addressed surgically. Care should be taken to preserve the normal skin and adenexa for lining the canal, but if this is not adequate, skin grafts should be used to prevent healing by secondary intent. Overcorrection of stenosis is advised

(Selesnick S *et al* 1995). A retrospective survey of the post-operative course after canalplasty in eight patients (10 ears) showed this to be a satisfactory treatment with no recurrence of symptoms (Banerjee A R *et al* 1995). Canalplasty was the necessary procedure in the operation of overlay Tympanoplasty which could conduce to de-epithelization of the membrane, placement of fascia and prevention of the occurrence of cholesteatoma pearl (Peng B, Miao X *et al* 1995). Canalplasty can be done to remove or prevent re-accumulation of squamous debris as an adjunct and alternative to tympanoplasty for the treatment of tympanic membrane atelectasis and early cholesteatoma (Garside JA *et al* 1998).

Role of canalplasty in stapes surgery has been studied by many authors. Canalplasty allows the surge onto have adequate exposure to identify the anterior malleal ligament and process, the inferior incudomalleal joint, the entire stapes including the pyramidal process and the round window niche (Linder TE, Fisch U 2007). Canalplasty for the exostosis of the external auditory meatus is a safe surgical option. Canalplasty, in such a situation, is a valid and effective management option (Sanna M *et al* 2004; House JW, Wilkinson EP 2008).

Comparison of hearing improvement in type 1 tympanoplasty with and without canalplasty shows canalplasty gives 9 dB gain in hearing in comparison to without canalplasty. canalplasty also gives better visualization, better graft placement and better post-operative care in case of tympanoplasty (Vijayendra H. *et al* 2008). Like any other surgical procedure there can be post-operative problems. In canalplasty, the re-stenosis may be there. Partial, transient, delayed facial palsy occurs sometimes, probably due to thermal injury transmitted from the burr. A full, spontaneous recovery of facial function occurred in each case (Lavy J *et al* 2001). The most frequent long-term complication of canalplasty is re-stenosis of the external auditory canal. The importance of sealing any inadvertently opened mastoid air cells, in order to avoid the late complication of canal cholesteatoma, should be emphasized (Martinez Del Pero M, Donnelly N *et al* 2009). The anatomic conditions that cause a predisposition to transient facial palsy include absence of the stapes and the presence of positional anomalies of the facial nerve. Although some patients display transient facial palsy after surgery, all patients fully recover (Ushio M, Takeuchi N. 2004). Fisch technique of canalplasty can prevent atresia or stenosis of external auditory canal after surgery for congenital aural atresia and regular follow-up anti-inflammatory management are necessary after surgery (Zhang Z *et al* 2007). Drill canalplasty via the postauricular approach minimizes complications (Lin Chung *et al* 2008). Overall canalplasty is a safe and effective technique for canal widening (Lavy J *et al* 2001).

Aims And Objectives

1. To study and compare the role of canalplasty in ear surgeries
2. To analyze the effectiveness of ear surgeries with canalplasty in terms of graft take up rates, hearing improvements and operative ease.
3. To estimate the success rate of ear surgeries with canalplasty.

MATERIALS AND METHODS

Study protocol

The work up for these cases consisted of a detailed history and a complete general physical, systemic and ENT examination. For all patients, routine blood examination, otoscopic examination and pure tone audiometry was done. Eustachian tube function was assessed and recorded clinically.

All the cases were operated by a consultant. Tympanoplasty was done through post auricular approach both by underlay or overlay grafting technique using autologous temporalis fascia as the graft material. Following canalplasty and grafting of tympanic membrane, the ear canal was packed with antibiotic soaked gel foam and mastoid dressing was done for 1 week post operatively. Mastoid dressing and sutures were removed on the seventh post-operative day and patient was discharged. Oral and local antibiotic was advised in all the cases. Patients were reviewed after 3 weeks for inspection of the operated ear. The second post-operative review was done at 3 months for a clinic-audiological assessment of the operated ear in respect to graft status, ear discharge and hearing improvement. The same procedure was also applied to the patient in control group.

Study Design

Prospective Study

Study Duration

One Year

Study Sample

The proposed study was carried out on in-house (admitted to the department for ear surgeries) and follow-up patients for hearing impairments due to chronic suppurative otitis media (CSOM), Otosclerosis, Exostoses, and osteoma of the external auditory canal etc.

STUDY METHOD

The canal was widened using conical cutting and diamond burrs in patients of study group along with primary surgical procedure, whereas in control group only primary surgical procedure was done.

Inclusion criteria

1. Chronic Suppurative Otitis Media (CSOM)
2. Chronic inactive tubotympanic otitis media with pars tensa perforation for > 3 weeks
3. Hearing impairment with intact tympanic membrane (Otosclerosis, Ossicular disruption)

Exclusion criteria

1. Chronic Otitis Media in active phase
2. Pregnancy
3. Hearing impairment due to noise trauma
4. Any other systemic illness which is contra-indicative for ear surgery, e.g. Blood dyscrasia, uncontrolled diabetes, hypertension, AIDS, HBsAg.

Tools for measurement of outcomes

Objective assessment

1. Tuning fork test
2. Pure Tone audiometry
3. Impedance audiometry
4. Oto-endoscopy

Statistical analysis

Continuous data were summarized as Mean ± SD (standard deviation) while discrete (categorical) in no and %. The categorical groups were compared by chi-square (χ^2) test. Pearson correlation analysis was used to assess association between the variables. A two-tailed ($\alpha=2$) p value less than 0.05 ($p<0.05$) was considered statistically significant. All analyses were performed on SPSS software (windows version 17.0).

OBSERVATION AND RESULTS

60 cases of Tympanoplasty, 12 cases of Stapedotomy and 8 cases of exostosis, osteoma, and complete stenosis were studied during a period of 1 year from September 2009 to August, 2010 in the Department of ENT, King George Medical Universtiy, Lucknow.

Summary of cases

In our study comparative analysis of functional outcomes of canalplasty in ear surgeries were done. A total of 100 cases were taken up for study but results are based upon outcomes of 80 patients only as 20 cases did not turn up for follow up. The study group comprised of 60 patients of tympanoplasty; divided into two groups: 30 patients in which canalplasty was done while in rest 30 patients, canalplasty was not done. Out of 12 patients of stapedotomy, canalplasty was done in 6 patients and in the rest of the patient canalplasty was not done and they comprised of control group(Table-1).

Table 1 Summary of cases

	Canalplasty done	Canalplasty not done
Tympanoplasty	30	30
Stapedotomy	6	6
Eac stenosis,exostosis Osteoma	8	-

Distribution of patients according to age

Maximum number of patients was seen in the age group of 21-30 years (37.5%), with a mean age of 26.4 yrs. The youngest patient was 10 years and the oldest 65 years(Table-2).

Table 2 Distribution of patient according to age

Age (in yrs)	No of Patients	Percentage
11-20	20	25%
21-30	30	37.5%
31-40	12	15%
41-50.	12	15%
>50yrs	6	7.5%
Total	80	100

Distribution of patient according to sex

Of the total 80 patients studied, a slight female predominance is observed in the ratio of 1.1:1(Table 3).

Table 3 Distribution of patient according to sex

Sex	No. Of patients	Percentage
Females	42	52.5%
Males	38	47.5%
Total	80	100%

Status of external auditory canal

Of all the total 80 cases studied, canalplasty was done in total 44 cases in which anterior hump, posterior hump, inferior hump and combinations were found(Table-4).

Table 4 status of external auditory canal

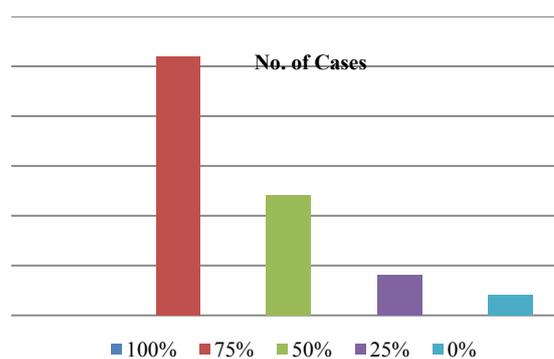
status of external auditory canal	no of cases
anterior hump	25
posterior hump	5
inferior hump	4
stenosis	2
anterior and inferior hump	2
inferior and posterior hump	2
exostosis	2
osteoma	2
total	44

Pre-operative visualization of tympanic membrane

All the patient studied were examined with the help of head mirror and bull's eye lamp and it was found that complete visualization of tympanic membrane was seen in only few patient. On the basis of visibility of tympanic membrane, all the patient were divided into five groups by dividing tympanic membrane into 4 parts by drawing 3 vertical line or by drawing 3 horizontal line and taking each quadrant as 25% of the whole tympanic membrane (Table-5 & Graph-1).

Table 5 Pre-operative visualization of tympanic membrane

Visualization of tympanic membrane	No. of Cases
100%	0
75%	26
50%	12
25%	4
0%	2



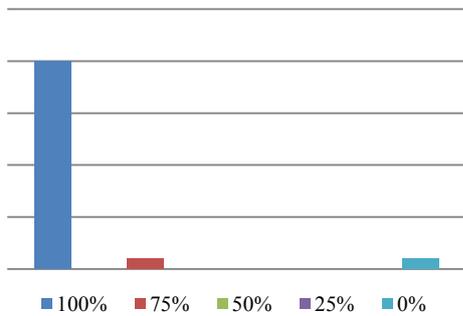
GRAPH 1 Pre-operative visualization of tympanic membrane

Post-operative visualization of tympanic membrane in cases after canalplasty

Out of a total of 44 cases in which later canalplasty was done, in 26 cases only 75% of tympanic membrane was visualized, in 12 cases only 50% was visualized due to bony hump and in 2 cases there was complete Stenosis. After canalplasty, 100 % visualization of Tympanic Membrane and annulus was seen in 40 cases and in 2 cases Stenosis reoccurred after 3 weeks (Table 6 & Graph 2).

Table 6 post-operative visualization of tympanic membrane in cases after canalplasty

Visualization of tympanic membrane	No. of Cases
100%	40
75%	2
50%	0
25%	0
0%	2(Restenosis)



Graph 2 Post-operative visualization of tympanic membrane in cases after canalplasty

Audiological assessment

In this study a maximum that is 22 cases were between 25 – 40 dB hearing loss, 15 cases were with 41-55 dB hearing loss and 7 were with 56-70 dB hearing loss (Table 7). After surgery along with canalplasty, in 20 cases hearing threshold came below 25 dB while in control group only 10 cases showed > 25 dB (Table 8). AB gap also reduced more in case of canalplasty as compared to cases without canalplasty (Table 9, 10, 11). It was found that in cases without canalplasty average gain in AB gap was 9.1 dB and with canalplasty, average gain in AB gap was about 15.1 dB. After surgery along with canalplasty, in 20 cases hearing threshold came below 25 dB while in control group only 10 cases showed > 25 dB. AB gap also reduced more in case of canalplasty as compared to cases without canalplasty

Table 7 Pre-operative hearing status in all cases of tympanoplasty and stapedotomy

Hearing impairment	Cases (n=44)	Control (n=36)
25 – 40 db	22	17
41 – 55 db	15	13
56 – 70 db	7	6
71 – 90 db	-	-

Table 8 post-operative hearing status in all cases of tympanoplasty and stapedotomy

Hearing impairment	Cases(n=44)	Control (n=36)
< 25 db	20	10
25 - 40 db	12	14
41 – 55 db	10	7
56 - 70 db	2	5
71 – 90 db	-	-
> 90	-	-

Table 9 Change in hearing in all subjects

Hearing impairment	Pre op cases (44)	Post op cases (44)	Pre op control (n=36)	Post control (n=36)
< 25 dB	-	20	-	10
25 - 40 dB	22	12	15	14
41 - 55 dB	15	10	10	7
56 - 70 dB	7	2	6	5
71 – 90 dB	-	-	-	-

Table 10 Pre-operative status of AB-gap in all cases of tympanoplasty and stapedotomy

Ab gap	Cases(n=44)	Control(n=36)
0 – 10		2
11 - 20 dB	8	8
21 – 30 dB	15	12
31 - 40 dB	14	8
41 – 50 dB	7	6

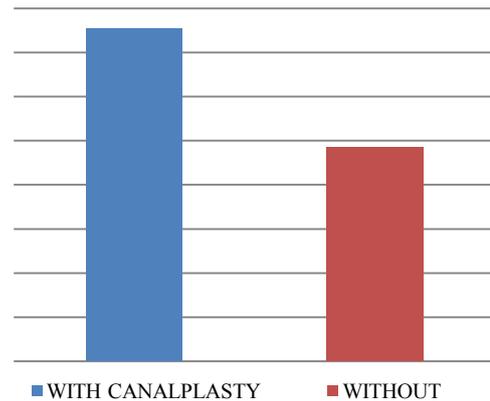
Table 11 Post-operative status of A-Bgap in all cases of tympanoplasty and stapedotomy

A-b gap	Cases(n=44)	Control(n=36)
0 – 10	7	2
11 – 20 dB	20	10
21 – 30 dB	9	12
31 – 40 dB	6	8
41 – 50 dB	2	4

In our study pure tone audiometry was done prior to surgery and 3 months after surgery it was found that in cases without canalplasty average gain in AB gap was 9.1 dB and with canalplasty average gain in AB gap was about 15.1 dB (Table 12 & Graph 3).

Table 12 Gain in A-B gap in cases with canalplasty and without canalplasty

Gain in db	With canalplasty(n=44)	Average Gain in db	Without Canalplasty	Average gain
0-10	7	-	31	
11-20	31	15.1	5	9.7
21-30	6	-	0	



Graph 3 Gain in AB GAP in cases with canalplasty and without canalplasty

In our study tympanoplasty was done in 60 cases, canalplasty was done in 30 cases, and in 30 cases, canalplasty was not done. The result shows that the success rate of tympanoplasty with canalplasty is 83% which can be due to better visualization in placing the graft preventing lateralization of the graft, ease of post-operative care and promotes healing (Table 13).

Table 13 Comparison of Success rates of tympanoplasty with or without canalplasty

Success rate of tympanoplasty with or without canalplasty	Total cases(n=30)	Graft take up	Graft failure	% Success
Tympanoplasty with canalplasty	30	25	5	83%
Tympanoplasty without canalplasty	30	18	12	60%

DISCUSSION

In our study comparative analysis of functional outcomes of canalplasty in ear surgeries were done. In the present study maximum numbers of cases were in the age group of 21-30 years (37.5%) with a mean age of 26.4 years. In a study of 87

cases of ear by Ortegren(1963), maximum numbers of patients were in the age group > 40 years (42.5%). The reason behind this could be that society has become more health conscious and due to presence of newer diagnostic tools the disease is diagnosed at early stage and managed accordingly.

In our series, 12 surgeries were performed on patients more than 40 years and on 48 patients, who were less than 40 years. The graft take up rates were found to be 58% and 75% respectively excluding the confounding factors in patients > 40 years of age but statistically no significant difference was found. The result of our study matches with that of Ortegren (1963), in that after the age of 40 years, results of tympanoplasty are not as good as in younger patients.

In our study, maximum cases were of chronic suppurative otitis media (68%) followed by otosclerosis (13.6%), exostosis (9%) and 4.5% cases of EAC stenosis and osteoma. Among 60 cases of CSOM (TTD) disease, 5 type of perforations were found, in which maximum cases were of central perforation (68%) followed by posterior, anterior, inferior and then subtotal, in that order. Narrowing of canal was observed in 44 cases. The most common type of narrowing was bony hump, which was seen in 38 cases (86%) followed by exostosis, osteoma, and canal stenosis (14%). It was found that anterior hump was more common (65%) out of all of the bony hump cases. The reason behind that is Temporo-Mandibular joint come in anterior wall relations, so during development the glenoid fossa expands and leads to curvature in the anterior canal wall.

In our study, tympanic membrane was divided into 4 quadrants and ear was examined with naked eye with aural speculum, otoscope and under a microscope. The subjects' heads were turned to the maximum right or left as possible and the microscope was tilted accordingly to confirm the inability to see the annulus all around. Subjects where the full annulus could not be seen were taken as case with canal wall hump. Out of a total of 44 cases, in 26 cases only 75% of tympanic membrane was visualized, in 12 cases only 50% was visualized due to bony hump and in 2 cases there was complete Stenosis.

After canalplasty, 100 % visualization of tympanic Membrane and annulus was seen in 40 cases and in 2 cases Stenosis reoccurred. In this study a maximum that is 22 cases were between 25 – 40 dB hearing loss, 15 cases were with 41-55 dB hearing loss and 7 were with 56-70 dB hearing loss. After surgery along with canalplasty, in 20 cases hearing threshold came below 25 dB while in control group only 10 cases showed > 25 dB. A-B gap also reduced more in case of canalplasty as compared to cases without canalplasty. The reason behind that is, in normal human middle ear sound pressure in the ear canal is higher than sound pressure within the middle ear. Tympanic membrane motion is driven by this pressure difference. The bony hump in the canal causes reduction in the sound pressure difference in the ear canal which leads to pressure difference across the tympanic membrane, with a subsequent reduction in tympanic membrane and ossicular motion alters the normal hearing mechanism. After canalplasty, hump is removed and the sound pressure of the canal increases which is required for normal movement of tympanic membrane. Thus, canalplasty helps in improving the hearing. Statistically, it is seen that

improvements seen in patients in which canalplasty was done is significant as compared to cases without canalplasty.

In our study pure tone audiometry was done prior to surgery and 3 months after surgery it was found that in the cases without canalplasty, average gain in AB gap was of 9.1 dB and with canalplasty average gain increased to about 15.1 dB. This study matches with the study of H. Vijayendra *et al*, 2008. Our study result shows that the success rate of tympanoplasty with canalplasty is 83% in comparison to the cases where canalplasty was not done. In those cases, the success rate was 60%. This result showed that canalplasty have role in favourable outcome of tympanoplasty.

CONCLUSIONS

Authors would like to conclude on the basis of study that all ear surgeries should be combined with canalplasty as it gives

- Better visualization - this facilitates placement of graft particularly in the anterior anchoring of graft in subtotal perforation
- Easier post-operative care- there will be no problem with the self-cleansing mechanism of external auditory canal
- Better exposure- for stapedotomy and ossiculoplasty
- Time gain- the time spent for performing a canalplasty is compensated by the time gained by improved exposure during grafting of tympanic membrane.
- Prevent lateralization of tympanic membrane- Adequately performed canalplasty improves the visualization of lateralized drum and makes it easier to identify the level of tympanic sulcus.
- Promotes healing.

References

1. Peng B, Miao X et al. Experience of canalplasty during the overlay tympanoplasty. *Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi*. 2009 Feb;23(4):151-3.
2. Ortegren. Myringoplasty. *Acta Otolaryngology*. 1963.Suppl: 193, 1-41.
3. J. B. Booth (1973). Tympanoplasty: Factors in post-operative assessment. *The Journal of Laryngology & Otology*, 87, pp 27-67.
4. Selesnick S, Nguyen TP, Eisenman DJ (1998) Surgical treatment of acquired external auditory canal atresia. *Am J Otol* 19(2):123-130.
5. Packer P. What is best in myringoplasty; underlay or overlay dura or fascia. *J Laryngology and otology*. 1982; 96:25-4.
6. Gibb AG, Chang SK. Myringoplasty A review of 365 operations. *J Laryngol otol*;96(10):915-30:oct 1982.
7. Garside JA, Antonelli PJ, Singleton GT. canalplasty for chronic tympanic membrane atelectasis. *Am J Otolaryngol*. 1999 Jan-Feb;20(1):2-6.
8. Emmett, John R. Age as a factor in the success of tympanoplasty: A comparison of outcomes in the young and old: *Ear, Nose & Throat Journal*; Jul 99, Vol. 78 Issue 7, p480.
9. Parisier SC1, Bent JP 3rd. canalplasty. *Otolaryngol Clin North Am*. 1999 Jun;32(3):457-69.

10. Lavy J, Fagan P. canalplasty: review of 100 cases. *J Laryngol Otol.* 2001 Apr. 115(4):270-3.
11. Zhang Z, Zheng Y, Chen S, Liu X. Fisch technique in prevention of external pore stenosis and atresia after surgery for congenital aural atresia. *Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi.* 2007 Nov;21(22): 1018-9.
12. Hetzler DG. External auditory exostoses: evaluation and treatment. *Otolaryngol Head Neck Surg.* 2008 Sep;139(3):482; author reply 482.
13. House JW, Wilkinson EP. External auditory exostoses: evaluation and treatment. *Otolaryngol Head Neck Surg.* 2008 May; 138(5):672-8.
14. Zhang Z, Zheng Y, Chen S, Liu X. Fisch technique in prevention of external pore stenosis and atresia after surgery for congenital aural atresia. *Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi.* 2007 Nov; 21(22): 1018-9.
15. Martinez Del Pero M, Donnelly N, Antoun N, Axon P. Canal wall cholesteatoma following canalplasty. *J Laryngol Otol.* 2009 Oct; 123(10):1174-6.
16. Sanna M, Russo A, Khrais T, Jain Y, Augurio AM. canalplasty for severe external auditory meatus exostoses. *J Laryngol Otol.* 2004 Aug; 118(8):607-11.
17. Garside JA, Antonelli PJ, Singleton GT. canalplasty for chronic tympanic membrane atelectasis. *Am J Otolaryngol.* 1999 Jan-Feb;20(1):2-6.
18. Selesnick S, Nguyen TP, Eisenman DJ. Surgical treatment of acquired external auditory canal atresia. *Am J Otol.* 1998 Mar;19(2):123-30.
19. Linder T, Fisch U. A Checklist for Surgical Exposure in Stapes Surgery: How to Avoid Misapprehension. In Arnold W, Häusler R (eds): *Otosclerosis and Stapes Surgery.* *Adv Otorhinolaryngol.* Basel, Karger, 2007, vol 65, pp 158-163.
20. Vijayendra H., Ittop C. J., Sangeetha R. Comparative study of hearing improvement in type 1 tympanoplasty with and without canalplasty. *Indian J. Otolaryngol. Head Neck Surg.* (October–December 2008) 60:341–344.
21. Gerlinger I., Rath G. et al. Myringoplasty for anterior and subtotal perforation. *Eur Arch Otorhinolaryngology,* 2006.
22. Jung T, Kim YH, Kim YH, Park SK, Martin D. Medial or medio-lateral graft tympanoplasty for repair of tympanic membrane perforation. *International Journal of Pediatric Otorhinolaryngology,* Volume 73, Issue 7, July 2009, pp. 941-943.
23. Moore GF, Moore IJ, Yonkers AJ, Nissen AJ. Use of full thickness skin grafts in canalplasty. *Laryngoscope.* 1984 Aug; 94(8):1117-8.
24. Birman CS, Fagan PA. Medial canal stenosis--chronic stenosing external otitis. *Am J Otol.* 1996 Jan; 17(1):2-6]
25. Cremers WR, Smeets JH. Acquired atresia of the external auditory canal. Surgical treatment and results. *Arch Otolaryngol Head Neck Surg.* 1993 Feb; 119(2):162-4.
26. Banerjee AR1, Moir AA, Jervis P, Narula AA. A canalplasty technique for the surgical treatment of chronic otitis externa. *Clin Otolaryngol Allied Sci.* 1995 Apr; 20(2):150-2.
27. Ortegren. Myringoplasty. *Acta Otolaryngology.* 1963 Suppl: 193, 1-41.

