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Original Article

Outcome Variation of CO₂ Laser and Microdrill-Assisted Stapedotomy in Otosclerosis

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Abstract:

Background: CO₂ laser and microdrill-assisted stapedotomy are widely performed procedures in otolaryngology practice. However, definite information regarding surgical advances, postoperative results, complications and how and in which patients these surgical techniques should be exclusively used is a source of continuous discussion.

Aim: To compare the outcome of CO₂ laser and microdrill-assisted stapedotomy in patients with otosclerosis.

Methodology: We enrolled 26 cases as study sample on the basis of selection criteria. All these patients were evaluated by a complete clinical head and neck examination, preoperative oto-microscopic evaluation, pure tone audiometry (PTA) and a high-resolution CT scan. One group of patients were treated by CO₂ laser stapedotomy, and another group by microdrill-assisted stapedotomy. Fisher's Exact test and Student's t-test were done as appropriate, and a p-value <0.05 was considered as the level of significance.

Results: Maximum patients 9(69.2%) and 7(53.8%) were in the age group of 20-30 years in Group A (CO₂ laser stapedotomy) and Group B (Microdrill assisted stapedotomy), respectively. The difference in the mean postoperative air-bone gap was not statistically significant (p=0.679) between the groups. All surgical procedures compared in our study showed the surgical success of > 90%. In present study, 8(61.5%) and 9(69.2%) of the study subjects presented with tinnitus in the CO₂ and Microdrill groups, respectively. 1(7.7%) and 1(7.7%) of the study subjects presented with dizziness in both groups, respectively. At 3 months postoperative follow-up, only 1(7.7%) case in the CO₂ laser group and 4(30.8%) cases in the Microdrill group developed complications. Among them, 1 (7.7%) and 2(15.4%) cases developed permanent vertigo in CO₂ and Microdrill groups, respectively. 1(7.7%) case developed chorda tympani injury, and

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1(7.7%) case developed worsened tinnitus in the Microdrill group. No significant ($p>0.05$) difference was observed between the groups regarding postoperative complications at 3 months.

Conclusion: After analyzing the results of the present study, it can be concluded that there is no significant difference between CO₂ laser and microdrill-assisted stapedotomy in terms of hearing outcome and complication.

Keywords: Otosclerosis, Stapedotomy, CO₂ laser stapedotomy, Microdrill assisted stapedotomy.

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Introduction:

Otosclerosis is a disease of the otic capsule and ossicles of the middle ear. It is the most common cause of stapes fixation. It is primarily a bone disease involving the cochlea and labyrinth. It is characterized by progressive focal dysplasia with destruction, remodelling, and, finally, sclerosis of the endochondral bone of the labyrinthine capsule. The disease begins in the anterior part of the oval window. It extends to the annular ligament and stapes, where it causes stapes bone ankylosis, which results in increased ossicular chain rigidity and conductive hearing loss^{1,2}.

Otosclerosis is more common in Caucasians and Asians than in Africans. The incidence of otosclerosis in Caucasians varies from 3.4% to 13%. It is a disorder in which genetic and environmental etiologic factors are involved. There is an autosomal dominant inheritance pattern for otosclerosis. Many environmental factors have been implicated in the aetiology of otosclerosis, including infectious causes such as the measles virus, hormones related to puberty, pregnancy, menopause, and nutritional factors such as fluoride intake. It is known that pregnancy can trigger the onset of otosclerosis or make it worse. The period of onset is mainly between 20 to 45 years of age, with a higher prevalence in women than in men. It usually affects both ears (85% - 90%).^{1,3,4}

Schwartz sign is sometimes associated with otospongiosis, which represents the active phase of the disease^{5,6}. The definitive diagnosis can only be made peroperatively by observing the mechanical fixation of the stapes.⁷

Available treatments for otosclerosis are surgery, hearing aid, and fluoride therapy⁷. With the development of the stapes mobilization technique, proposed by Rosen, and the oval window fenestration, proposed by Shea in 1958, otosclerosis surgery has constantly been improving.^{8,9,10}

Patients with otosclerosis highly demand surgical management to improve their hearing level and avoid hearing aids. Nowadays, stapedotomy has become the preferred technique. It can be performed by various surgical methods such as perforator, microdrill, laser or piezoelectric device. The surgical method depends on the surgeon's experience and the availability of material. In microdrill-assisted stapedotomy, fenestration of the stapes footplate is performed by a skeeter drill. In CO₂ laser stapedotomy, fenestration of the stapes footplate is done by a single-shot CO₂ laser. The microdrill technique is preferred by many surgeons because of its availability, appreciation of contact, and it is also safer in difficult cases such as narrow footplate or facial nerve dehiscence. Although damage to the inner ear as a result of mechanical trauma and

footplate avulsion always remain the risks of the drilling technique¹¹. Barbara et al.¹² reported that CO₂ laser is a safe and alternative technology for stapedotomy. There are many advantages of the CO₂ laser, such as high precision and low risk of stapedectomy or floating footplate, as there is no contact between the instrument and footplate. However, the limitations of the use of the laser technique are the heating effect on labyrinthine fluids and facial nerve canal dehiscence, which makes it at risk of injury. However, the choice of surgical technique should strongly depend on the outcome and complications. Air-bone gap (ABG) closure was shown to be better with laser fenestration than conventional techniques by Wegner et

al.¹³. Bone conduction damage was shown to be one of the risks of the thermal effect of the CO₂ laser with multiple shots by Brase et al.¹⁴, but Cuda et al.¹⁵ found less damage to the inner ear in favour of the laser technique.

Materials & Methods:

This Prospective Observational study was done in Department of Otolaryngology-Head & Neck Surgery, Bangabandhu Sheikh Mujib Medical University from Jan 2021 to Jun 2022. Patients of ages between 20-50 years with the diagnosis of Otosclerosis having AC threshold d" 70dB and BC d" 30 dB & AB gap more than 15dB were included. Otosclerosis with associated disease like perforated TM, SNHL, prior surgery and only hearing ear were excluded.

Results:

Table-I: Distribution of study subjects according to age (N=26)

Age (Years)	Group A (n=13)	Group B (n=13)	p-value
20-30	9 (69.2%)	7 (53.8%)	
31-40	3 (23.1%)	4 (30.8%)	
41-50	1 (7.7%)	2 (15.4%)	
Mean ± SD	28.23±5.95	30.0±6.54	0.478 ^{ns}

Group A: CO₂ laser stapedotomy

Group B: Microdrill-assisted stapedotomy

Table-II: Distribution of study subjects according to sex (N=26)

Sex	Group A (n=13)	Group B (n=13)	p-value
Male	4 (30.8%)	2 (15.4%)	0.352 ^{ns}
Female	9 (69.2%)	11 (84.6%)	
Total	13 (100.0%)	13 (100.0%)	

Table-III: Distribution of study subjects according to clinical presentation (N=26)

Presentation	Group A (n=13)	Group B (n=13)	p-value
Hearing loss	13 (100.0%)	13 (100.0%)	-
Tinnitus	8 (61.5%)	9 (69.2%)	0.680 ^{ns}
Dizziness	1 (7.7%)	1 (7.7%)	1.000 ^{ns}

Table-IV: Mean pure tone audiometry (Air conduction) of study subjects in both groups (N=26)

Air conduction (dB)	Pre-operative	Post-operative		Preoperative vs 6 weeks ^b p value	Preoperative vs 3 months ^b p value
		At 6 weeks	At 3 months		
Group A (n=13)	54.10±4.39	33.58±1.74	28.33±29.1	<0.001 ^s	<0.001 ^s
Group B (n=13)	55.00±3.53	34.74±1.65	29.07±2.83	<0.001 ^s	<0.001 ^s
^a p value	0.573 ^{ns}	0.097 ^{ns}	0.536 ^{ns}		

Data were expressed as Mean±SD. Unpaired and paired student 't' test were performed to compare between the groups. a= Unpaired student 't' test, b= Paired student 't' test, ns= not significant, s=significant, n=total no. of subjects in each group, N= total study subjects.

Table-V: Mean pure tone audiometry (bone conduction) of study subjects in both groups (N=26)

Bone conduction (dB)	Pre-operative	Post-operative		Preoperative vs 6 weeks ^b p value	Preoperative vs 3 months ^b p value
		At 6 weeks	At 3 months		
Group A (n=13)	23.85±4.22	23.52±4.0	22.18±4.05	0.192 ^{ns}	0.198 ^{ns}
Group B (n=13)	24.10±2.86	22.69±2.31	22.78±2.38	0.035 ^s	0.006 ^s
^a p value	0.860 ^{ns}	0.521 ^{ns}	0.938 ^{ns}		

Data were expressed as Mean±SD. Unpaired and paired student 't' test were performed to compare between the groups. a= Unpaired student 't' test, b= Paired student 't' test, ns= not significant, s=significant, n=total no. of subjects in each group, N= total study subjects.

Table-VI: Comparison of ABG (dB) between groups and within the group (N=26)

ABG (dB)	Pre-operative	Post-operative		Preoperative vs 6 weeks ^b p value	Preoperative vs 3 months ^b p value
		At 6 weeks	At 3 months		
Group A (n=13)	30.26±5.17	10.06±4.44	6.15±3.75	<0.001 ^s	<0.001 ^s
Group B (n=13)	30.90±5.12	12.05±2.98	6.79±4.04	<0.001 ^s	<0.001 ^s
^a p value	0.753 ^{ns}	0.192 ^{ns}	0.679 ^{ns}		

Data were expressed as Mean±SD. Unpaired and paired student 't' test were performed to compare between the groups. a= Unpaired student 't' test, b= Paired student 't' test, ns= not significant, s=significant, n=total no. of subjects in each group, N= total study subjects.

Table-VII: Distribution of study subjects according to the final hearing outcome based on ABG at 3 months (N=26)

ABG (dB)	Group A (n=13)	Group B (n=13)	p-value
≤10 dB (Success)	12 (92.3%)	12 (92.3%)	1.000 ^{ns}
11-20 dB (Satisfactory)	1 (7.7%)	1 (7.7%)	
Total	13 (100.0%)	13 (100.0%)	

Data were expressed as frequency and percentage. Fisher exact test was performed to compare the groups. ns= not significant, n=total no. of subjects in each group, N= total study subjects.

Table-VIII: Distribution of study subjects according to per-operative complications (N=26)

Variable	Group A (n=13)	Group B (n=13)	p-value
No complication	13(100%)	13(100%)	-
Complications	0(0.0%)	0(0.0%)	
Footplate avulsion	0(0.0%)	0(0.0%)	-
Incus luxation	0(0.0%)	0(0.0%)	-

Table-IX: Distribution of study subjects according to complications at immediate postoperative period (N=26)

Variable	Group A (n=13)	Group B (n=13)	p-value
No complication	8(61.5%)	3(23.1%)	0.112 ^{ns}
Complications	5(38.5%)	10(76.9%)	
Chorda tympani injury	1(7.7%)	3(23.1%)	0.587 ^{ns}
Facial nerve palsy	0(0.0%)	0(0.0%)	-
Perilymph fistula	0(0.0%)	0(0.0%)	-
Vertigo	4(30.8%)	6(46.2%)	0.687 ^{ns}
Worsened tinnitus	0(0.0%)	1(7.7%)	1.000 ^{ns}
TM perforation	0(0.0%)	0(0.0%)	-

Table-X: Distribution of study subjects according to complications at 6 weeks (N=26)

Variable	Group A (n=13)	Group B (n=13)	p-value
No complication	10(76.9%)	5(38.5%)	0.112
Complications	3(23.1%)	8(61.5%)	
Chorda tympani injury	1(7.7%)	3(23.1%)	0.351 ^{ns}
Facial nerve palsy	0(0.0%)	0(0.0%)	-
Perilymph fistula	0(0.0%)	0(0.0%)	-
Temporary Vertigo	2(15.4%)	4(30.8%)	0.352 ^{ns}
Worsened tinnitus	0(0.0%)	1(7.7%)	1.000 ^{ns}
TM perforation	0(0.0%)	0(0.0%)	-

Table-XI: Distribution of study subjects according to complications at 3 months (N=26)

Variable	Group A (n=13)	Group B (n=13)	p-value
No complication	12(92.3%)	9(69.2%)	0.319 ^{ns}
Complications	1(7.7%)	4(30.8%)	
Chorda tympani injury	0(0.0%)	1(7.7%)	0.308 ^{ns}
Facial nerve palsy	0(0.0%)	0(0.0%)	-
Perilymph fistula	0(0.0%)	0(0.0%)	-
Permanent Vertigo	1(7.7%)	2(15.4%)	0.539 ^{ns}
Worsened tinnitus	0(0.0%)	1(7.7%)	1.000 ^{ns}
TM perforation	0(0.0%)	0(0.0%)	-

Discussion:

Stapedotomy is the standard surgical intervention for the treatment of otosclerosis. The stapes surgery aims to improve hearing and minimize the risk of hearing damage or other complications related to footplate fenestration. Thermal effects of CO₂ laser¹⁶ and mechanical contact injury in case of microdrill stapedotomy are the factors that may affect the hearing outcome.

In present study, maximum of patients, 9 (69.2%) and 7(53.8%), were in the age group of 20-30 years in Group A (CO₂ laser stapedotomy) and Group B (Microdrill assisted stapedotomy), respectively. The mean age was 28.23±5.95 years in Group A and 30.0±6.54 years in Group B. Age is an important factor related to postoperative results of stapes surgery. Fisch (2009) found that the best results were obtained in patients aged less than 50 years. This could be due to better capability of resistance or recovery from surgery-related damage and is substantiated by Altamami et al.¹¹, who concluded that significantly better functional results of stapedotomy were found in younger patients, which is consistent with the current study.

In this study, female patients were predominant in both groups, 69.2% and 84.6% in Group A and Group B, respectively. Pauli et al.¹⁷ reported that women are more affected than men due to endocrine factors involved in the etiopathogenesis of otosclerosis.

In our study, 57.7% population was housewife, 30.8% service holder, and 11.5% student in their occupations. Fakir et al.⁶ found that 31.25% of the population was student, 15.62% service holder and 25% housewife in their occupations.

In present study, otosclerosis patients presented with hearing impairment, tinnitus

and dizziness. Among them, bilateral otosclerosis was common. Xie J. et al.¹⁸ agreed with our findings.

In this study, mean preoperative air-conduction was 54.10±4.39 & 55.00±3.53, mean preoperative bone conduction was 23.85±4.22 & 24.10±2.86, mean preoperative air-bone gap was 30.26±5.17 & 30.90±5.12 in Group A & Group B respectively. There was no significant difference between groups in terms of mean preoperative pure-tone air-conduction (p=0.573), mean preoperative pure-tone bone-conduction (p = 0.860), and preoperative air-bone gap (p=0.753). Altamami et al.¹¹ agreed to our findings.

Postoperative air-conduction, bone-conduction and air-bone gap were decreased at 3 months of follow-up from 6 weeks follow-up values in both groups. The difference was statistically significantly (p<0.05) in case of air-conduction in both groups. In case of bone-conduction, statistically significant (p<0.05) difference was found in Group B. In case of Postoperative air-bone gap (ABG), there is no statistically significant (p>0.05) difference between the two surgical techniques. Postoperatively in both groups (92.3% in the CO₂ group, 92.3% in the microdrill group), a high percentage of patients achieved the level of ABG within 10 dB, which is a successful result. Altamami et al.¹¹ reported high percentages of patients achieving closure of ABG up to 20 dB, 95% for microdrill group patients and 96% for CO₂ patients.

About 8(61.5%) and 9(69.2%) of the study subjects presented with tinnitus in the CO₂ laser and microdrill group, respectively. 1(7.7%) and 1(7.7%) of the study subjects presented with dizziness in both groups, respectively. At immediate postoperative period, 5(38.5%) cases in Group A and 10(76.9%) cases in Group B developed complications. Among them, 1 (7.7%) and 3(23.1%) cases developed chorda tympani

injury and 4(30.8%) and 6(46.2%) cases developed temporary vertigo in both groups, respectively. 1(7.7%) case developed worsened tinnitus in Group B. No significant ($p>0.05$) difference was observed between the groups regarding immediate postoperative complications. At 6 weeks, only 3(23.1%) cases in Group A and 7(53.8%) cases in Group B developed complications. Among them, 1(7.7%) and 3(23.1%) cases developed chorda tympani injury and 2(15.4%) and 4(30.8%) cases developed temporary vertigo in both groups, respectively. 1(7.7%) case developed worsened tinnitus in Group B. No significant ($p>0.05$) difference was observed between the groups regarding postoperative complication at 6 weeks.

At 3 months postoperative follow-up, only 1(7.7%) case in the CO₂ laser group and 4(30.8%) cases in the microdrill group developed complications. Among them, 1(7.7%) and 2(15.4%) cases developed permanent vertigo in CO₂ and microdrill groups, respectively. 1(7.7%) case developed chorda tympani injury, and 1(7.7%) worsened tinnitus in the microdrill group. No significant ($p>0.05$) difference was observed between the groups regarding postoperative complications at 3 months. Matkovic et al.¹⁹, in a comparison of outcomes of CO₂ laser versus conventional stapedotomy, found postoperative vertigo in 26% of the laser group and 55% of the conventional group. They attributed this difference to the lesser risk of mechanical trauma to the inner ear using CO₂ laser. Badran et al.²⁰ compared CO₂ laser versus mechanical techniques (skeeter and microperforator) for Stapedotomy. They observed the occurrence of vertigo in the postoperative period. They found that 2.8% of the patients in the Laser group had post-operative vertigo compared to 12.2% of patients in the mechanical group, which they attributed to lesser footplate manipulation and greater

precision of piston placement in the laser groups.

Even though patients often experience relief from tinnitus after stapes surgery, some patients have aggravated or new problems with tinnitus after surgery. In this study, 1(7.7%) patient experienced worsened tinnitus in the microdrill group. Other studies have reported a 2.5% to 6% worsening of tinnitus²¹.

Conclusion:

After analyzing the results of the present study, it can be concluded that CO₂ laser has less complication rate compared to microdrill assisted stapedotomy. Hearing outcome is same in both techniques.

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