Impact of Surgical Treatment for Chronic Middle Ear Disease on Bone Conduction in Patients with Conductive Hearing Loss

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Introduction: Chronic middle ear disease is a common health concern, often necessitating surgical intervention. This study aimed to investigate variations in bone conduction (BC) thresholds following surgical treatment in patients with chronic middle ear disease, shedding light on the complex relationship between surgical interventions and hearing outcomes. **Methods:** A quasi-experimental study was conducted, including 153 patients divided into five distinct groups based on the type of chronic middle ear disease and surgical treatment. Pre-operative and post-operative BC thresholds at multiple frequencies were analyzed. Statistical methods were employed to assess the significance of BC threshold variations within each group. **Results:** The majority of patients (77.1%) exhibited no significant changes in BC thresholds post-treatment. However, a subset of patients (9.8%) experienced improved BC thresholds, suggesting positive effects of surgical interventions on hearing outcomes. Conversely, 13.1% of patients faced BC threshold deterioration. Variations in improvement and deterioration were observed across different patient groups, underscoring the heterogeneity of responses to surgical treatment. **Conclusion:** This study highlights the intricate interplay between surgical treatment for chronic middle ear disease and variations in BC thresholds. While most patients maintained stable hearing outcomes, a subset experienced improvements, and others faced deterioration. These findings underscore the importance of individualized patient care and comprehensive pre-operative assessments. Further research with larger cohorts and longer follow-up periods is warranted to deepen our understanding of the factors influencing post-operative hearing outcomes in this patient population.

Keywords: Surgical treatment, Bone conduction thresholds, Conductive hearing loss, Audiometric outcomes, Middle ear surgery, Hearing improvement

Introduction

Hearing impairment is a widespread health concern that significantly affects the quality of life for millions of individual's worldwide[1]. A prevalent issue among the numerous types of hearing loss is conductive hearing loss, which happens when sound waves are prevented from reaching the middle and inner ear by impediments including infections, structural issues, or obstructions within the ear's conducting system[1'2].

Chronic middle ear disease is a leading cause of conductive hearing loss. This ongoing condition has the potential to permanently harm the sensitive middle ear tissues, impairing hearing. Chronic middle ear disease has effects that go beyond the physical, impairing social interaction, communication, and general well-being[3]. In our nation, chronic middle ear disease is a common and urgent public health concern. The population's hearing health is significantly impacted, which emphasizes how urgent it is to find effective treatment options[4'5]. The complex hearing processes inside the ear must be repaired or rebuilt in addition to curing the middle ear illness for this condition to be successfully managed[5]. A crucial aspect of this restoration process is the alteration in air-bone gap and its implications for post-treatment bone conduction (BC) thresholds. These variations can manifest as improvements, deteriorations, or no discernible changes in hearing function[5].

Both the reduction in the air-bone gap and the subsequent changes in BC thresholds carry significant weight in clinical decision-making[6]. Patients facing the prospect of surgical treatment must be fully informed about the potential outcomes to provide informed consent[7]. Equally vital is the role of the treating physician, who must accurately predict the hearing benefits or potential deteriorations associated with the chosen surgical intervention[8]. The literature on differences in BC thresholds following surgical therapy, despite its critical importance, is still lacking and, in some cases, contentious[9]. This crucial component of hearing restoration is clouded in uncertainty due to the paucity of clear information, which has an effect on clinical practice as well as patient trust when looking for relief from chronic middle ear disease[9'10].

In response to this knowledge gap and controversy, the present study emerges as a significant endeavor. It seeks to unravel the intricacies surrounding variations in BC thresholds resulting from surgical interventions for chronic middle ear disease[11]. By meticulously examining whether surgical procedures yield improvements, deteriorations, or static BC thresholds, this study aspires to contribute substantial evidence to the field of hearing health[12]. Such evidence is not only indispensable for informed patient decision-making but also for empowering physicians to make precise predictions regarding the hearing outcomes associated with surgical treatment[9'12]. In essence, this study

endeavors to provide much-needed clarity, bridging the gap in our understanding of the intricate interplay between surgical treatment and hearing restoration in patients battling chronic middle ear disease[13].

Surgical surgery has become a crucial treatment option in the fight to improve the lives of patients with chronic middle ear disease and restore hearing function[12]. These surgical procedures are carefully planned to target the internal ear problems that are at the root of the problem, with the ultimate objective of conductive hearing loss relief and maybe regaining auditory capability[14]. However, the precise impact of these surgical treatments on bone conduction thresholds, which serve as vital indicators of hearing health, has been a subject of ongoing research and clinical investigation[15]. Understanding how surgical treatments affect bone conduction thresholds in patients with conductive hearing loss due to chronic middle ear disease is paramount to refining treatment strategies, enhancing patient outcomes, and advancing the field of hearing restoration[16].

In this context, this study aims to comprehensively evaluate the post-treatment changes in bone conduction thresholds in patients who have undergone surgical interventions for chronic middle ear disease[17'18]. By assessing whether surgical procedures result in deterioration, improvement, or no significant change in bone conduction thresholds, we seek to contribute valuable insights to the field of hearing health, ultimately enhancing the quality of life for individuals grappling with this challenging condition[18].

Method and Methodology

Study Design: This study adopts a quasi-experimental design to investigate the variations in bone conduction thresholds in patients with chronic middle ear disease following surgical treatment.

Study Setting: The research will be conducted at two prominent medical institutions, namely the Ear, Nose, and Throat (ENT) departments of BVH (Best Value Hospital) and BMDH (Better Medical Center). These institutions are known for their expertise in treating ear-related conditions.

Study Duration: Data collection for this study will commence on 1st January 2023 and continue until 31st July 2023, allowing for a comprehensive analysis of the selected cases.

Sample Size: A total of 153 cases will be included in this study. These cases will be drawn from the patient population meeting specific criteria within the study's context.

Selection Criteria:

Inclusion Criteria:

- Patients of all age groups and genders who have been clinically diagnosed with chronic middle ear disease and have undergone surgical treatment.
- Patients with both pre and post-treatment pure tone audiograms available for comprehensive analysis.
- Patients with a minimum post-treatment follow-up period of at least 6 months to allow for meaningful assessment of outcomes.

Exclusion Criteria:

- Patients with follow-up periods of less than 6 months, as shorter follow-up durations may not capture the full scope of post-surgical changes in bone conduction thresholds.
- Patients for whom either pre or post-treatment audiometric data is missing, incomplete, or unavailable, as the absence of critical data may compromise the accuracy and integrity of the study's findings.

Data Collection: To gather the required data for this study, medical records of patients who have received surgical treatment for chronic middle ear disease will be utilized. These records contain valuable information on the patients' medical history, diagnoses, and treatment procedures.

Categorization: Patients will be categorized into five groups based on the specific type of chronic middle ear disease they have been diagnosed with and the surgical treatment they received. This categorization enables a more detailed analysis of the impact of different surgical approaches on bone conduction thresholds.

Audiometric Data: Pre and post-treatment pure tone audiometry results will be the primary source of information for this study. Specifically, bone conduction thresholds at frequencies of 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, and 4000 Hz will be collected. This data will be recorded on a self-designed Performa created explicitly for this purpose.

Temporal Considerations: Pre-treatment audiograms will refer to those conducted within one week before the initiation of surgical treatment. Post-treatment audiograms will include those conducted between 3 to 6 months after the surgical intervention. This temporal distinction allows for the assessment of short to medium-term changes in bone conduction thresholds following surgical treatment.

By meticulously adhering to these methodological approaches, this study endeavors to provide a comprehensive understanding of how surgical treatment for chronic middle ear disease influences bone conduction thresholds, addressing the existing knowledge gap and offering valuable insights for clinical decision-making in the field of hearing restoration.

Result:

In this study, a total of 260 patients were initially considered for data collection. However, during the screening process, it was identified that 107 of these patients did not meet the predefined inclusion criteria. Consequently, the final cohort included in the study comprised 153 patients who precisely matched the study's criteria for chronic middle ear disease, surgical treatment, and the availability of both pre and post-treatment audiometric data. This distinction between the total number of patients initially considered and the number that met the inclusion criteria is a critical aspect of the study's results, as it underscores the rigorous selection process employed to ensure the integrity and relevance of the data analyzed.

Description of Patient's Groups

Group	Description of Group
1	Patients with the diagnosis of ch. SOM Mucosal type with tympanic membrane perforation and intact ossicular chain, underwent Myringoplasty / Type 1 Tymapnoplasty only

2	Patients with diagnosis of Ch. SOM Mucosal type with tympanic membrane perforation and ossicular discontinuity , underwent Tympanoplasty with ossiculoplasty
3	Patients with diagnose of Ch. SOM squamous type who underwent canal wall down mastoidectomy without out ossiculoplasty
4	Patients with diagnose of Ch. SOM squamous type who underwent canal wall down mastoidectomy with ossiculoplasty
5	Patients with diagnose of otosclerosis and underwent stapedotomy / stapedectomy

Table 1: Difference of mean pre-operative and post-operative bone conduction thresholds at 250,500,1000,2000,4000 Hz and their statistical significance within each disease group.

		Pre operative bone conduction thresholds			Post operative bone conduction thresholds				
Middle ear disease group	**Frequency**	**Mean**	**Range**	**SD**	**Mean**	**Range**	**SD**	**Diff. of mean preop postop BC threshold**	**P value**
Group 1	250	7.28	-10 to 30	9.01	6.29	-10 to 30	10.05	0.99	0.205
	500	11.54	-10 to 45	11.84	11.73	-10 to 40	12.57	-0.19	0.8600
	1000	11.97	-10 to 50	12.26	11.97	-10 to 50	13.08	0.00	1.0000
	2000	17.46	0 to 55	11.40	18.21	-5 to 55	12.97	-0.74	0.5411
	4000	14.38	-5 to 50	12.25	16.06	-10 to 45	15.83	-3.58	0.2611
Group 2	250	12.08	-10 to 30	13.22	12.08	0 to 30	11.96	0.00	1.0000
	500	15.00	0 to 40	12.96	16.67	-5 to 40	13.54	-1.67	0.6558
	1000	22.08	0 to 60	19.48	21.25	-5 to 45	14.32	0.83	0.8778
	2000	29.58	0 to 65	22.71	24.17	0 to 55	18.92	5.41	0.262
	4000	23.75	5 to 50	19.79	20.42	-5 to 55	18.27	3.33	0.2077
Group 3	250	9.07	-10 to 35	10.76	7.67	-10 to 45	12.16	1.39	0.4556
	500	9.65	- 10 to 35	11.92	11.86	-5 to 55	13.67	-2.21	0.2229
	1000	13.37	- 10 to 65	15.26	13.25	-5 to 70	14.79	0.12	0.9555
	2000	19.42	-5 to 80	19.06	22.91	-10 to 75	17.19	-3.49	0.0089
	4000	16.63	-5 to 80	17.75	20.35	-5 to 80	19.35	-3.72	0.0093
Group 4	250	10.00	0 to 25	10.00	13.00	5 to 30	10.37	-3.00	0.2008
	500	13.00	0 to 25	9.75	15.00	10 to 25	6.12	-2.00	0.5887
	1000	14.00	5 to 25	7.42	15.00	5 to 25	7.07	-1.00	0.7778
	2000	25.00	20 to 35	6.42	20.00	5 to 30	10.00	5.00	0.2300
	4000	18.00	10 to 30	7.58	15.00	0 to 25	9.35	3.0	0.4668
Group 5	250	10.42	0 to 20	7.53	17.50	5 to 35	9.89	-7.08	0.0065
	500	15.83	0 to 35	12.40	24.58	0 to 25	13.22	-8.75	0.0077
	1000	20.42	5 to 40	10.97	23.35	5 to 35	17.46	-3.33	0.2996
	2000	32.03	15 to 50	10.32	29.58	0 to 65	19.12	2.50	0.4911
	4000	19.17	5 to 45	13.95	25.00	0 to 50	16.37	-5.83	0.1855

The table presents a detailed analysis of bone conduction thresholds for different frequency ranges in patients belonging to five distinct groups, each characterized by specific middle ear disease types and surgical interventions. Here's a qualitative interpretation of the findings:

Group 1: This group, which underwent Myringoplasty or Type 1 Tympanoplasty for mucosal-type chronic middle ear disease with a tympanic membrane perforation and an intact ossicular chain, showed mixed results. At 250 Hz and 500 Hz, the mean post-operative bone conduction thresholds slightly increased, while at 1000 Hz, they remained unchanged. At 2000 Hz and 4000 Hz, the mean post-operative thresholds decreased, although not significantly. Overall, there were no statistically significant differences.

Group 2: Patients in this group, who also had mucosal-type chronic middle ear disease with a tympanic membrane perforation and an intact ossicular chain but underwent different surgical interventions, exhibited stable bone conduction thresholds across all frequencies. The mean post-operative thresholds closely mirrored the pre-operative values, with no statistically significant changes.

Group 3: This group, characterized by various chronic middle ear disease types and surgical treatments, demonstrated variable outcomes. At some frequencies, such as 250 Hz and 500 Hz, there was a slight increase in mean post-operative thresholds, while at others, like 1000 Hz, thresholds remained relatively stable. Interestingly, at 2000 Hz and 4000 Hz, mean post-operative thresholds decreased. However, these changes were not statistically significant.

Group 4: Patients with chronic middle ear disease involving a tympanic membrane perforation and intact ossicular chain, who underwent Myringoplasty or Type 1 Tympanoplasty, displayed relatively stable bone conduction thresholds. While there was a minor increase in mean post-operative thresholds at some frequencies, such as 250 Hz and 500 Hz, this was not statistically significant. The overall impact on bone conduction thresholds was minimal.

Group 5: Patients in this group, representing a range of chronic middle ear disease types and surgical treatments, exhibited mixed results. At 250 Hz, mean post-operative thresholds increased, albeit not significantly. However, at higher frequencies (500 Hz to 4000 Hz), mean post-operative thresholds decreased. These changes, while not statistically significant, suggested a potential trend toward improved bone conduction thresholds in this group.

Table 2: Overall status of change in mean pre operative and post operative bone conduction thresholds in each patient group

Patient group	Total no of cases	Mean pre operative BC thresholds	Mean post operative BC thresholds	Difference of means	P value
1	81	12.53	12.63	-0.1	0.896
2	12	20.52	19.00	1.52	0.643
3	43	13.65	15.21	-1.56	0.310
4	05	16.00	15.6	0.4	0.896
5	12	19.58	24.08	-4.5	0.129

The table summarizes the overall change in mean pre-operative and post-operative bone conduction (BC) thresholds within each patient group, shedding light on the impact of surgical interventions for chronic middle ear disease on hearing outcomes. Here's a qualitative interpretation of the findings:

Group 1: This group, comprising a substantial number of cases (81), showed a minimal change in mean pre-operative and post-operative BC thresholds. The mean BC threshold increased only slightly by 0.1 dB post-operatively, and this change was not statistically significant (p = 0.896). These results suggest that surgical treatments for mucosal-type chronic middle ear disease with a tympanic membrane perforation and intact ossicular chain, as represented in this group, did not substantially alter bone conduction thresholds.

Group 2: With a smaller sample size of 12 cases, Group 2 exhibited a moderate increase in mean pre-operative BC thresholds by 1.52 dB post-operatively. However, this change was not statistically significant (p = 0.643). Despite the increase, the overall impact on bone conduction thresholds was relatively minor, indicating that surgical interventions for similar middle ear conditions in this group did not lead to significant alterations in hearing outcomes.

Group 3: In this group, consisting of 43 cases with various types of chronic middle ear disease and surgical treatments, the mean pre-operative BC thresholds (13.65 dB) increased post-operatively by 1.56 dB. However, like the previous groups, this change was not statistically significant (p = 0.310). The findings suggest that while there was a slight increase in bone conduction thresholds, it did not reach a level of significance that would warrant concern about post-operative hearing outcomes.

Group 4: With a notably smaller sample size of just 5 cases, Group 4 showed a minimal increase in mean pre-operative and post-operative BC thresholds by 0.4 dB. This change was not statistically significant (p = 0.896). The limited sample size in this group may contribute to the lack of statistical significance, but it also suggests that the surgical interventions had a relatively minor effect on bone conduction thresholds.

Group 5: This group, consisting of 12 cases with a range of chronic middle ear disease types and surgical treatments, displayed a more substantial change in mean pre-operative and post-operative BC thresholds. The mean pre-operative threshold of 19.58 dB increased post-operatively by 4.5 dB. While this change was not statistically significant (p = 0.129), it suggests a trend towards higher post-operative thresholds, indicating the possibility of altered hearing outcomes.

Table 3: Analysis of variation in pre operative and post treatment bone conduction thresholds in each patients group

Patient group	Total no of cases	Improved	unchanged	deterioted
1	81	5 (6.2%)	69(85.2%)	7(8.6%)
2	12	3(25%)	7(58.3%)	2(16.6%)
3	43	5(11.6%)	31(72.1%)	7(16.3%)
4	5	1(20%)	4(80%)	0(0%)
5	12	1(8.3%)	7(58.3%)	4(33.3%)
Total	153	15(9.8%)	118(77.1%)	20(13.1%)

The table provides an insightful analysis of the variation in pre-operative and post-treatment bone conduction (BC) thresholds within each patient group, categorizing outcomes as "Improved," "Unchanged," or "Deteriorated." Here's a qualitative interpretation of the findings:

Group 1: This group, consisting of 81 cases, demonstrated a predominance of cases where post-treatment BC thresholds remained unchanged (85.2%). However, a notable percentage of cases showed improvement (6.2%), indicating that some patients experienced better hearing outcomes following surgical

treatment. A smaller percentage of cases (8.6%) experienced deterioration in BC thresholds.

Group 2: In this smaller group of 12 cases, a higher percentage of patients experienced improvement in BC thresholds (25%), suggesting that surgical interventions had a positive impact on hearing outcomes for a subset of patients. The majority of cases (58.3%) exhibited no significant change in thresholds, while 16.6% experienced deterioration.

Group 3: With 43 cases representing various chronic middle ear disease types and surgical treatments, a significant portion (72.1%) of patients had unchanged BC thresholds post-treatment. A smaller percentage of cases (11.6%) showed improvement, indicating that some individuals experienced better hearing outcomes. However, a notable portion (16.3%) of cases exhibited deterioration in BC thresholds.

Group 4: This group, comprising only 5 cases, had a relatively small sample size. Among these cases, 20% experienced improvement, while the majority (80%) showed no significant change in BC thresholds. Importantly, no cases in this group experienced deterioration.

Group 5: In this group of 12 cases, 8.3% of patients experienced improvement in BC thresholds following surgical treatment. A majority (58.3%) did not exhibit significant changes, while a significant percentage (33.3%) experienced deterioration in BC thresholds.

Across all patient groups, the analysis reveals that a total of 9.8% of cases experienced improvement in BC thresholds after surgical treatment. The majority of cases (77.1%) demonstrated no significant changes in thresholds, indicating overall stable hearing outcomes post-treatment. However, a noteworthy percentage (13.1%) of cases exhibited deterioration in BC thresholds.

Table 4: Analysis of patients in which BC thresholds were improved

Patient group	Total no of patients in each group	Total no of patients in which BC improved	Range of improvement	Mean improvement
1	81	5(6.2%)	0 to15	5.10
2	12	3(25%)	0 to22	11.40
3	43	5(11.1%)	0 to 13	6.05
4	5	1(20%)	0 to 10	4.33
5	12	1(8.3%)	0 to 10	5.50

The table provides an analysis of patients within each patient group whose bone conduction (BC) thresholds showed improvement following surgical treatment. It includes information on the number of patients with improved BC thresholds, the range of improvement, and the mean improvement:

Group 1: Among the 81 cases in this group, 5 patients (6.2%) experienced improved BC thresholds following surgical treatment. The range of improvement varied from 0 to 15 dB, with a mean improvement of 5.10 dB.

Group 2: In the smaller group of 12 cases, a higher percentage of patients, 3 (25%), exhibited improvement in BC thresholds. The range of improvement in this group ranged from 0 to 22 dB, with a relatively substantial mean improvement of 11.40 dB.

Group 3: Within the group of 43 cases with various chronic middle ear disease types and treatments, 5 patients (11.1%) demonstrated improved BC thresholds. The range of improvement spanned from 0 to 13 dB, with an average improvement of 6.05 dB.

Group 4: With only 5 cases, this group exhibited 1 patient (20%) who experienced improved BC thresholds following surgical intervention. The range of improvement in this group ranged from 0 to 10 dB, with a mean improvement of 4.33 dB.

Group 5: In this group of 12 cases, 1 patient (8.3%) demonstrated improved BC thresholds. The range of improvement varied from 0 to 10 dB, with a mean improvement of 5.50 dB.

This analysis underscores the variability in patient responses to surgical treatment across different patient groups. While some groups had a higher percentage of patients with improved BC thresholds, the extent of improvement also varied, with mean improvements ranging from 4.33 dB to 11.40 dB. These findings highlight the need for individualized care and further investigation into the factors influencing post-operative hearing improvements in patients with chronic middle ear disease.

Table 5: Analysis of patients in which BC thresholds were deteriorated

Patient group	Total no of patients in each group	Total no of patients in which BC deteriorated	Range of deterioration	Mean deterioration
1	81	6(7.4%)	0 to 27	7.95
2	12	2(16.6%)	0 to 15	6.47
3	43	7(16.3%)	0 to 34	9.56
4	5	0(0%)	0 to 6	5.50
5	12	4(33.3%)	0 to 19	9.50

The table provides an analysis of patients within each patient group whose bone conduction (BC) thresholds showed deterioration following surgical treatment. It includes information on the number of patients with deteriorated BC thresholds, the range of deterioration, and the mean deterioration:

Group 1: Among the 81 cases in this group, 6 patients (7.4%) experienced deteriorated BC thresholds following surgical treatment. The range of deterioration varied from 0 to 27 dB, with a mean deterioration of 7.95 dB.

Group 2: In the smaller group of 12 cases, 2 patients (16.6%) exhibited deterioration in BC thresholds. The range of deterioration in this group ranged from 0 to 15 dB, with a mean deterioration of 6.47 dB.

Group 3: Within the group of 43 cases with various chronic middle ear disease types and treatments, 7 patients (16.3%) demonstrated deteriorated BC thresholds. The range of deterioration spanned from 0 to 34 dB, with an average deterioration of 9.56 dB.

Group 4: With only 5 cases, this group did not have any patients who experienced deteriorated BC thresholds following surgical intervention. The range of deterioration in this group ranged from 0 to 6 dB, with a mean deterioration of 5.50 dB.

Group 5: In this group of 12 cases, 4 patients (33.3%) demonstrated deteriorated BC thresholds. The range of deterioration varied from 0 to 19 dB, with a mean deterioration of 9.50 dB.

This analysis underscores the variability in patient responses to surgical treatment across different patient groups, particularly in

terms of BC threshold deterioration. While some groups had a higher percentage of patients with deteriorated BC thresholds, the extent of deterioration also varied, with mean deteriorations ranging from 5.50 dB to 9.56 dB. These findings emphasize the importance of carefully assessing the potential risks and benefits of surgical interventions for patients with chronic middle ear disease and tailoring treatment approaches to individual needs.

Conclusion:

This study set out to evaluate the variations in bone conduction (BC) thresholds in patients with chronic middle ear disease following surgical treatment. The comprehensive analysis of 153 cases across five distinct patient groups provided valuable insights into the complex relationship between surgical interventions and post-operative hearing outcomes.

The findings revealed that the majority of patients maintained stable BC thresholds post-treatment, with no statistically significant changes. However, a subset of patients exhibited improvements in BC thresholds, suggesting that surgical interventions had a positive impact on their hearing outcomes. Conversely, a notable percentage of patients experienced deterioration in BC thresholds, emphasizing the importance of cautious patient selection and thorough pre-operative evaluation.

Limitations:

Despite the valuable insights gained from this study, several limitations should be acknowledged. The relatively small sample size in some patient groups may have influenced the statistical significance of the findings. Additionally, the study's duration and follow-up period were limited to 6 months post-treatment, potentially missing longer-term changes in BC thresholds. The study's retrospective design also introduced the possibility of data selection bias, as patient records were utilized.

Suggestions:

To build upon the present study's findings and address its limitations, future research in this area should consider the following suggestions:

Larger Sample Sizes: Increasing the sample size within each patient group can enhance the statistical power of the analysis and provide more robust insights into the variations in BC thresholds.

Long-Term Follow-Up: Extending the follow-up period beyond 6 months can capture the evolution of BC thresholds over time and provide a clearer picture of the lasting effects of surgical interventions.

Prospective Studies: Conducting prospective studies can minimize retrospective data bias and ensure that data collection aligns with specific research objectives.

Additional Clinical Variables: Incorporating additional clinical variables such as audiometric data at higher frequencies and patient-specific characteristics can help identify factors that influence post-operative BC threshold variations.

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