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COCHLEAR IMPLANTATION COMPLICATIONS: SUB-PERIOSTEAL TECHNIQUE VERSUS WELL-DRILLING TECHNIQUE; A BETTER MODALITY IN PEDIATRIC PATIENTS

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Abstract

Objective

To evaluate the safety, complications, stability, cosmetic outcomes, and long-term results of pediatric cochlear implantation, focusing on implant bed techniques.

Place and duration of study: *ENT Department of a tertiary care hospital in Rawalpindi from June 2024 to November 2024*

Methodology

Pediatric patients severe to profound congenital sensorineural hearing loss (≥90 dB on PTA or ASSR) were included. All patients had failed prior hearing aid trials and had normal middle ear anatomy. Intraoperative variables and postoperative outcomes were assessed through clinical, radiological, and functional follow-up.

Results

A total of 70 patients underwent cochlear implantation, with 36 in the subperiosteal pocket technique (SPT) group and 34 in the well-drilling technique (WD) group. Intraoperative complications were low, including dural exposure (5.6% SPT, 2.9% WD, P = 0.532) and CSF leaks (P = 1.000). Postoperative complications included wound dehiscence (5.6% SPT, 2.9% WD, P = 0.533), infections (8.3% SPT 2.9% WD, P = 0.256), and devices migration (2.9% WD, P = 0.317). Cosmetic outcomes were excellent in 72.2% (SPT) and 70.6% (WD, P = 0.758). For long-term outcomes, the mean hearing threshold was 29 ± 7 dB (SPT) and 31 ± 9 dB (WD, P = 0.471), with significant speech improvement and high patient satisfaction (91.7% SPT, 94.1% WD, P = 0.745).

Conclusion

Pediatric cochlear implantation is a safe and effective procedure with low complication rates, excellent implant stability, favorable cosmetic outcomes, and significant improvements in auditory and speech performance.

INTRODUCTION

A cochlear implant is an electrical device that transforms sound energy into electrical energy, thereby stimulating the auditory nerve. Cochlear implantation has revolutionized the management of severe to profound sensorineural hearing loss in pediatric patients, offering significant improvement in speech perception, language development and quality of life. However, surgical approaches for implant bed preparation continue to evolve, aiming to minimize complications and optimize long-term complications in children.[1]

Traditionally, the well-drilling technique has been the standard method, involving the creation of a bony recess to house the implant receiver-stimulator.[2] Although effective, it carries potential risk of dura exposure, bleeding, device migration, increased operative time and thermal injury to surrounding structures.[3]

The subperiosteal pocket technique, introduced as an alternative, avoids drilling into the skull by creating a tight pocket beneath the periosteum to secure the device.[4] This minimally invasive approach has gained attention due to its reduced risk of trauma, shorter operative time, decreased post-operative complications (such as hematoma or wound dehiscence) and better cosmetic outcomes. Pediatric patients with their thinner skull bones and higher risks of device migration, may particularly benefit from this approach. However, device migration might occur with this technique.[5]

However, the potential for device migration remains a concern with the subperiosteal technique. A study conducted by Shavit et al. (2021) in New York, which compared 179 patients undergoing well-drilling with 209 patients receiving the subperiosteal technique, found shorter surgery times with the latter.[2] Despite this, higher rates of surgical complications were noted, although these differences were not statistically significant after accounting for follow-up duration. Similarly, a 2023 retrospective study by Talal Al-Khatib et al. in Jeddah, Saudi Arabia, which involved 63 patients using the subperiosteal technique and 104 with the well-drilling technique, found no significant differences in intraoperative complications, electrode array performance, postoperative complications, or skin migration issues, despite faster surgery times with the well-drilling approach.[6]

The current study focused on intraoperative safety, postoperative complications, implant stability, cosmetic outcomes, and long-term device function. By evaluating the efficacy and safety of both methods, this research sought to inform surgical decisions, improve outcomes for pediatric patients, and add to the growing body of evidence in the field of otologic surgery. Thus, the objective of this study was to compare the complications and outcomes associated with the subperiosteal and well-drilling techniques in pediatric cochlear implant recipients.

METHODOLOGY

A prospective cohort analysis was conducted at the ENT Department of a tertiary care hospital in Rawalpindi from June 2024 to November 2024. The study population was pediatric patients aged 1 to 5 years who underwent cochlear implantation at the respective hospital department.

Inclusion criteria:

Children aged 1 to 5 years old with severe to profound congenital sensorineural hearing loss (≥ 90 dB on PTA or ASSR) who had already failed hearing aid trials and were medically viable to undergo surgery. Only patients who had normal anatomy of the middle ear radiographically, and actively followed up and evaluated throughout the study period were considered. The cases of revision cochlear implantation were also taken into consideration.

Exclusion criteria:

Children with a craniofacial anomaly that influenced the surgical procedure, middle ear or inner ear anomalies, those who had undergone previous mastoid surgeries or are unfit to undergo surgical procedures were excluded. Besides, patients that were neither actively followed up nor assessed within the study period were excluded.

A sample size of 70 pediatric patients was calculated based on the prevalence of 5% of the global population requiring rehabilitation for disabling hearing loss, as reported in recent global health statistics.[7] The calculation was performed using an online sample size calculator, assuming a 95% confidence level and a 5% margin of error.

The patients were categorized into two groups, according to the method of surgery used, namely: the Subperiosteal Technique (SPT) and the Well-Drilling Technique (WD) method. The surgeon discretion was the leading factor in determining the type of surgical procedure to be used, considering the anatomical factor in the patient, his previous medical history, and experience of the surgeon in the procedure. No predetermined

criteria were given on how patients should be assigned to either of the techniques, and both techniques were applied in a way that is similar to the normal clinical practice.

The study cohort was followed over a period of six months to assess the immediate and long-term outcomes. First assessment was conducted Post-surgery and during the first one month. Post operative assessment included immediate complications in the form of wound dehiscence, infection or hematoma. Additional follow-ups were conducted at three and six months after the surgery to assess the functionality and speech development in the long-term. Follow-ups included clinical and radiologic assessment of the implant location and any migration or implant failure. Also standardized questionnaires were used to evaluate hearing outcomes and cosmetic appearance.

Intraoperative variables were the length of surgery, blood loss, and complications, e.g., dural exposure, cerebrospinal fluid (CSF) leakage, and intraoperative bleeding. Complications were classified and documented after the operation, and wound healing, infection rates, and such problems, as the migration of the device, were considered. The quality of wound healing was determined by visual observation during follow-ups and identification of infection was conducted on clinical observations and laboratory tests as necessary. Migration of the devices was also measured radiologically and by clinical observation whereby the presence of displacement was noted.

Radiological imaging (e.g., CT scan or X-rays) was used to assess the stability of the implants at several follow-up levels to determine whether they have implant failure or are drifting. Also, hearing results were evaluated using aided hearing thresholds that were collected in the audiologic test. These tests were used to determine the hearing improvement following implantation comparing pre-implantation thresholds with the post-implantation performance. The perception of speech was also tested using standardized speech tests that were used to determine the capability of the child to recognize and repeat speech sounds, which is a fundamental test of cochlear implant performance.

The effectiveness of cosmetics was judged by parent/caregiver rating, and objective rating which considered the functionality of the implant site, any scarring and general satisfaction with the appearance of the child after the surgery.

Lastly, the long-term functioning of the device was assessed by measuring the periodic results of the aided hearing thresholds, speech performance, and overall satisfaction of the patients and parents. Insight into the effects of the cochlear implant on the everyday life of the child, speech development, and quality of life was collected using patient/parent satisfaction surveys, which were administered on every follow-up visit.

Data was analyzed using Statistical Package for the Social Sciences (SPSS) version 26.0. Descriptive statistics summarization was applied to demographic characteristics, surgical outcomes, and complications. The statistical tests (e.g., chi-square, t-tests) have determined the level of significance of difference between two groups as to the intraoperative complications, postoperative complications, implant stability, and long-term device functionality.

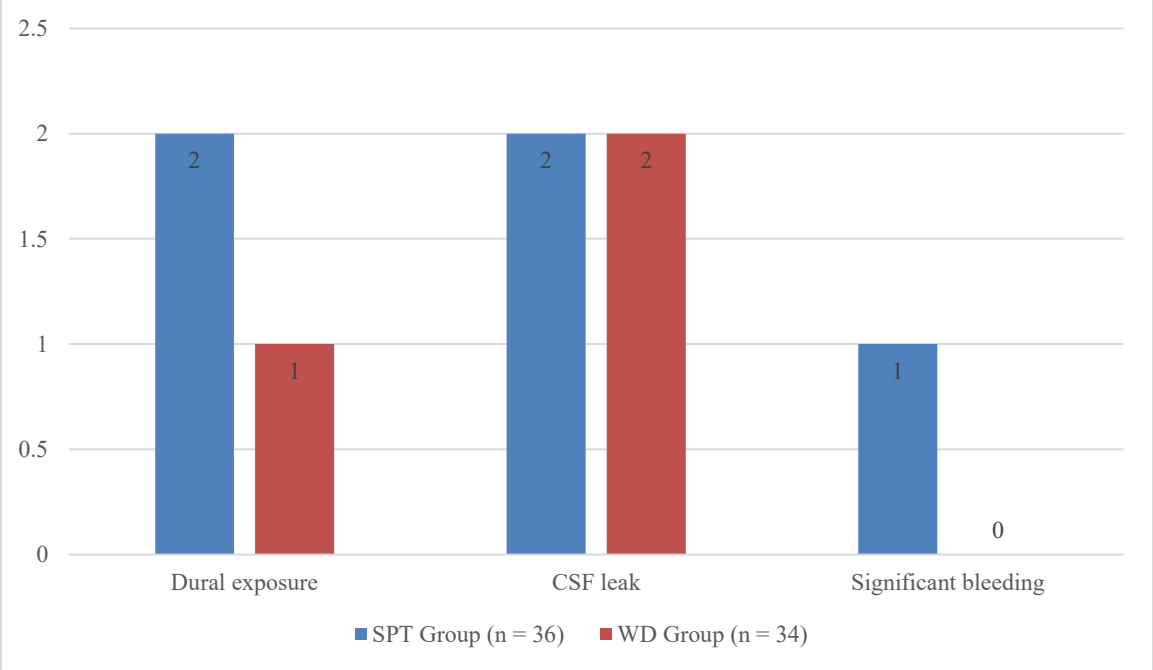
RESULTS

A total of 70 pediatric patients aged between 1 and 5 years underwent cochlear implantation during the study period. The study population was divided into two groups based on the surgical technique used: 36(51.4%) patients underwent Subperiosteal Technique (SPT) and 34 (48.5%) patients had undergone cochlear implantation by Well-Drilling Technique (WD).

Table- I : Demographic and Intraoperative Characteristics of the Study groups (n = 70)

Variable	SPT Group (n = 36)	WD Group (n = 34)	P-value
Mean age (years)	3.3 ± 1.2	3.1 ± 1.0	0.611
Gender (M/F)	26/10	24/10	0.08
Mean operative time (min)	130 ± 24	126 ± 21	0.422
Mean blood loss (ml)	50 ± 18	46 ± 16	0.507
Intraoperative complications	5 (13.9%)	4 (11.8%)	0.372
Types of Impalnts (Medel/ Cochlear)	20/16	18/16	0.09s

In terms of intraoperative complications, both techniques had similar incidence rates for some complications. Dural exposure was reported in 2 patients (5.6%) in the SPT group and 1 patient (2.9%) in the WD group (P = 0.532). CSF leaks occurred in 2 patients (5.6%) in both the SPT and WD groups (P = 1.000). Additionally, significant bleeding was noted in 1 patient (2.8%) in the SPT group, while there were no cases of significant bleeding in the WD group (P = 1.000).



In terms of postoperative complications, both techniques showed low incidence rates. Wound dehiscence occurred in 2 (5.6%) of the SPT group and 1(12.9%) of the WD group (P = 0.533), hematomas occurrence was same in both groups, and infections in 3 (8.3%) of the SPT group and 1 (2.9%) of the WD group (P = 0.256). Device migration was observed only in patient in the (P = 0.317). No significant differences were found between the two groups in terms of postoperative complications (P > 0.05).

Both groups exhibited high implant stability both clinically as well as radiologically. Cosmetic outcomes were favorable for both groups, with 26 (72.2%) of the SPT group and 24 (70.6%) of the WD group reporting excellent results (P = 0.758). While fair outcomes were reported in 5.6% of the SPT group and 8.8% of the WD group (P = 0.563). No significant differences were found between the groups in terms of cosmetic outcomes. For long-term functional outcomes, the mean aided hearing threshold was 29 ± 7 dB in the SPT group and 31 ± 9 dB in the WD group (P = 0.471). Speech outcomes improved in 32 (88.9%) of the SPT group and 30 (88.2%) of the WD group (P = 0.929), and high levels of satisfaction were

reported in 33 (91.7%) of the SPT group and 32 (94.1%) of the WD group (P = 0.745).

Table-II: Postoperative Complications, Implant Stability, Cosmetic Outcomes, and Long-Term Functional Results by Surgical Technique (n = 70)

Variable	SPT Group (n = 36)	WD Group (n = 34)	P-value
Postoperative complications			
Wound dehiscence	2 (5.6%)	1 (2.9%)	0.533
Hematoma	1 (2.8%)	1 (2.9%)	1.000
Infection	3 (8.3%)	1 (2.9%)	0.256
Device migration	0 (0%)	1 (2.9%)	0.317
No postoperative complications	30 (83.3%)	31 (91.2%)	0.432
Implant stability			
Radiologically stable	36 (100%)	34 (100%)	0.317
Clinically stable	36 (100%)	34 (100%)	0.317
Cosmetic outcomes			
Excellent	26 (72.2%)	24 (70.6%)	0.758
Good	8 (22.2%)	7 (20.6%)	0.811
Fair	2 (5.6%)	3 (8.8%)	0.563
Long-term outcomes			
Mean aided hearing threshold (dB)	29 ± 7	31 ± 9	0.471
Improved speech outcomes	32 (88.9%)	30 (88.2%)	0.929
High patient/parent satisfaction	33 (91.7%)	32 (94.1%)	0.745

DISCUSSION

The purpose of this study was to compare the intraoperative safety, postoperative complications, implant stability, cosmetic outcomes, and long-term device function of the subperiosteal (SPT) and well-drilling (WD) techniques in pediatric cochlear implantation.

Similar to findings from Sakaguchi et al. (2023), who noted the benefit of a tight temporalis pocket for anatomical fixation without the risk of bone drilling or inserting foreign objects[8], our study found no significant difference in intraoperative complications between the two techniques. This aligns with Ceylan et al. (2024), who also found no safety concerns associated with either technique.[9] In our study, dural exposure and CSF leaks were rare, occurring in a small proportion of patients, and there were no significant differences between the groups (P > 0.05). These findings are consistent with previous research, such as Kinoshita et al. (2024), who reported similar intraoperative complications with both techniques, despite some cases of mispositioned electrodes and migration in their cohort.

In terms of intraoperative time period, study by Al-Khatib et al. reported that the WD technique was faster overall. The authors emphasized the need for further long-term studies to validate these findings [6]. Yet in another similar study by Shavit et al. (2021), SPT was reported to be faster but associated with a potentially higher risk of complications, particularly device failure.[10] Long-term studies were recommended to confirm these differences.[2]

However, a notable contrast was observed in the postoperative complications. Our study found device migration in the WD group, although this was not statistically significant (P = 0.317), which mirrors the findings of systematic review on implantation techniques by Markodimitraki et al. (2021), who reported a higher revision rate due to device migration in the WD group compared to

the SPT group.[11] The scoping review by Bignami et al. (2025) also showed similar findings.[12] Interestingly, the rate of infections in the SPT group was higher, though the difference was not significant (P = 0.256), which aligns with the findings of Mostafa & Fiky (2024), who noted a slightly higher infection rate in the SPT group, possibly due to the larger surgical exposure.[13]

Both techniques exhibited high implant stability, with 100% radiological and clinical stability in both groups, supporting the results of Neagoş Nenec & Neagoş (2021) ; ElKaraksy et al. (2025) & Soloperto et al. (2025) who also reported excellent stability outcomes regardless of the technique.[14,15,16] This finding emphasizes that both techniques are equally effective in providing long-term stability for cochlear implants in pediatric patients.

In terms of cosmetic outcomes, our results were in line with those of Yu et al. (2024), who found no significant differences between the two groups regarding aesthetic results.[17] A high percentage of patients in both groups reported excellent or good cosmetic outcomes, demonstrating that both techniques provide favorable results in terms of appearance post-surgery. Regarding long-term functional outcomes, our study found no significant differences in hearing thresholds or speech outcomes between the two techniques, which is consistent with the studies of Lyu et al. (2019) and Corbett et al. (2025). [18,19] Both techniques resulted in improved speech outcomes and high levels of parental satisfaction, suggesting that neither technique is superior in terms of long-term functional efficacy.

The limitation of current study would be the diversity of surgeons involved, each with their own preferences for fixation methods, might explain some of the observed variations, such as differences in surgical time. In contrast to previous studies,[2,6,8] which reported a shorter surgical time with SPT, our study showed a slightly longer surgical time for SPT, likely due to factors such as device types used and surgeon experience.

Another challenge we faced was distinguishing between fixation-related complications and those unrelated to the surgical technique, particularly in cases of device failure. While some studies, like ElKaraksy et al. (2025), have linked fixation to device failure, others have pointed to non-fixation-related factors such as hardware or software issues. Our study did not find significant differences in the rate of device failure, which suggests that other factors, including micromovements or hardware issues, could contribute to failure.

CONCLUSION

Pediatric cochlear implantation is a safe and effective intervention that results in significant improvements in auditory performance, speech development, and quality of life. In this study, both implant bed preparation techniques demonstrated low complication rates, excellent implant stability, and favorable cosmetic outcomes. Careful surgical technique and appropriate patient selection remain crucial in minimizing complications, particularly in young children.

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