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Evaluating the efficacy of a novel periosteal flap in cochlear implantation: a retrospective surgical audit at a tertiary teaching hospital

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Abstract

Background This research aimed to critically evaluate the safety and reliability of a new periosteal flap technique in cochlear implantation through a comprehensive surgical audit. A surgical audit was conducted on a cohort of 39 patients who underwent cochlear implantation at a tertiary teaching hospital from July 2020 to September 2021. The novel periosteal flap technique was utilized in all cases. Patients were followed up for a period ranging from 2 to 12 months. For comparison, outcomes were assessed by comparing 51 children who had undergone cochlear implant surgery between July 2017 and June 2019, utilizing the anteriorly based palva flap. A scoring system was employed to evaluate various aspects, including ease of surgical exposure, flap maneuverability, ease of closure after device fixation, immediate postoperative complications (up to 24 h), and delayed complications (up to 30 days). Scores ranging from 1 (fair assessment) to 4 (excellent assessment) were assigned, with a maximum score of 18 indicating optimal outcomes.

Results The comparison between the two groups revealed a reduced incidence of emissary vein injury and easier wound closure after device fixation in the novel periosteal flap group ($p=0.000$). The mean total scores were significantly higher in the novel periosteal flap group, indicating superior outcomes. Only 2 out of 39 children with the novel flap experienced minor skin color changes during the initial postoperative period, which resolved within approximately 7 days. Major complications such as wound infection, hematoma, or device migration were not observed with the new periosteal flap. Furthermore, no flap revisions were required.

Conclusions The novel and innovative periosteal flap demonstrated both safety and reliability in cochlear implantation procedures. This well-vascularized and robust flap offered effective device coverage with minimal flap-related complications. Its time-saving nature further enhances its clinical utility. Additional validation from different medical centers would further corroborate the advantages of this easily implemented periosteal flap technique.

Level of evidence Level 3.

Keywords Cochlear implantation, Periosteal flap, Surgical technique, Device coverage, Flap-related complications, Hearing loss, Infection, Flap dehiscence

Background

Cochlear implant surgery has been a well-established treatment for individuals with profound sensorineural hearing loss for over four decades. During this time, several modifications to the surgical technique, including variations in the incision, periosteal flap type, and cochlear approach, have been proposed by various surgeons

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to improve outcomes [1–3]. The use of a post-aural incision in an S-shaped fashion along with an anterior-based flap has been widely adopted in cochlear implantation procedures [2, 3].

Despite these innovations aimed at enhancing the safety of cochlear implantation, complications related to the periosteal flap persist in the postoperative period. Surgeons have continued to explore novel flap techniques to improve surgical safety and provide optimal device coverage. For instance, Balkany et al. introduced the periosteal pocket technique, which secures the receiver stimulator unit without bone drilling [4]. Orhan et al. proposed a tailed palva flap within the subperiosteal pocket technique, aiming to enhance receiver stimulator unit stabilization and prevent migration [5]. Fouad et al. reported successful outcomes with a newly designed anteriorly based periosteal flap in 26 patients [6]. Additionally, Kirtane et al. utilized a posterosuperior-based periosteal flap in their cochlear implantation series [7].

Despite various techniques, the incidence of major flap-related complications ranges from 1.08 to 8.2% [8, 9]. Flap-related complications need treatment in forms of local wound care or debridement and flap cover and in severe cases. Explantation may be required. The study by W. Gawecki et al. reported revision surgery with explanation in 47.4% of the cases of major flap-related complications which is high [10]. In line with this ongoing pursuit for improved surgical techniques and avoid such complications, the present study aims to conduct a surgical audit of patients who underwent cochlear implantation utilizing a new periosteal flap technique introduced by our center [1]. The evaluation of outcomes associated with this novel flap approach is critical for advancing the safety and efficacy of cochlear implantation procedures.

Methods

Surgical technique

All procedures were done by a single surgeon under general anesthesia. Patients were positioned supine, with the head turned away from the operation site. A postauricular incision, approximately 3 cm long and 1.5 cm behind the retroauricular sulcus, extended from just below the hairline to the mastoid tip. Skin flaps were elevated subcutaneously to fully expose the periosteum. A curvilinear periosteal incision, starting posteriorly then curving anteriorly, allowed for the creation of anterior and posterior flaps (Fig. 1), with the anterior flap secured away from the operative field using 2-0 silk sutures.

The posterior flap was elevated to expose adequate bone for the receiver stimulator unit, which was secured in a bony well with monocortical holes for stability. Cochlear implantation followed the standard posterior tympanotomy round window cochleostomy approach.



Fig. 1 Showing the curvilinear vertical flap with its anterior part covering the device without tension



Fig. 2 The periosteal flap sutured over the device. The periosteal and skin sutures are at different planes

After implantation, the periosteal flap was sutured over the unit using 2-0 vicryl (Fig. 2), and the skin was closed with 3-0 monocryl subcuticular sutures. This method ensured complete device coverage and secure positioning within a tightly formed pocket [1].

This study presents a surgical audit involving 39 patients who underwent cochlear implantation at a distinguished tertiary teaching hospital between July 2020 and September 2021. The cochlear implant surgery utilized a novel periosteal flap technique described by Panda et al. in 2020 (Figs. 1 and 2), henceforth referred to as “Group N.” Among these patients, there were 37 children and 2 adults. For comparison, outcomes related to various flap issues were assessed by evaluating 51 patients (48 children and 3 adults) who underwent cochlear implant surgery between July 2017 and June 2019, utilizing the anteriorly based palva flap; this group is referred to as “Group P.” A comprehensive follow-up period ranging from 2 to 12 months was conducted for all patients.

To evaluate the postoperative outcomes, a standardized scoring system was employed, encompassing parameters such as ease of surgical exposure, surgical maneuverability of the flap, closure convenience after device fixation,

Table 1 The scoring sheet for the surgical audit of cases

1	Surgical exposure	Excellent Score = 4	Very good Score = 3	Good Score = 2	Fair Score = 1
2	Ease of working after exposure	4	3	2	1
3	Emissary vein injury	Yes = 0 No = 2			
4	Ease of closure of wound after device fixation	4	3	2	1
5	Any immediate complications (within 24 h) Hematoma/skin discolored	Yes = 0 No = 2			
6	Any delayed complications	Yes 0 No 2			

Total score = 18 points

Table 2 Showing the scores obtained for both the palva flap and the novel periosteal flap

Parameter	Palva flap	Novel periosteal flap
Surgical exposure	4	4
Emissary vein injury	0	2
Ease of working after exposure	2	4
Ease of closure of fixation of device	1	4
Immediate postoperative complications (skin discolored/wound hematoma)	2	0
Delayed complications, e.g., wound infection	0	2

immediate postoperative complications (up to 24 h), and delayed complications (up to 30 days). The scoring system assigned a rating from 1 (fair assessment) to 4 (excellent assessment), with the maximum possible score being 18, representing optimal outcomes (Table 1).

Comparisons between the two flap techniques were made using the scoring system, encompassing variables like surgical exposure, ease of surgical performance following exposure, incidences of emissary vein injury, ease of wound closure after device fixation, and both immediate and delayed complications (Table 2).

In this manner, the study aimed to elucidate the advantages and potential areas of improvement associated with the novel periosteal flap technique, thereby contributing valuable insights to the field of cochlear implantation procedures.

Results

A total of 39 cases, comprising individuals with bilateral profound hearing loss, underwent cochlear implantation utilizing the new periosteal flap technique. Among them, there were 37 children and 2 adults, with the children's age range spanning from 2 to 6 years and a mean age of 3.5 years. These patients were compared with 51

Table 3 Comparison of flap scores for the different devices used in our cohort

Device type	Standard palva flap n = 51	Novel periosteal flap n = 39
Nucleus straight electrode	27	5
CI 422 Cochlear Ltd	2	7
CI 522 Cochlear Ltd	None	3
CI 622	None	6
SONATA T100 implant MED-EL	None	6
HiFocus 1j electrode Advanced Bionics	11	7
Slim J Electrode Advanced Bionics	None	4
Digisonic implant	11	Nil
Sravan (DRDO)	None	1

individuals (48 children and 3 adults) who had undergone cochlear implantation using the anteriorly based palva flap between July 2017 and June 2019.

Table 3 displays the various types of devices used in both cohorts. The scoring system facilitated a comparative evaluation between the two flap techniques, as shown in Table 4. Significant differences were observed between the groups for emissary vein injury (chi-square: 27.960, *df* 1, *p* = 0.000) and ease of closure of wound after device fixation (chi-square: 90.000, *df* 1, *p* = 0.000). However, the variables of surgical exposure (*p* = 1), ease of working after exposure (chi-square: 1.564, *df* 1, *p* = 0.211), immediate complications within 24 h (chi-square: 0.076, *df* 1, *p* = 0.783), and delayed complications (chi-square: 2.373, *df* 1, *p* = 0.123) did not exhibit statistically significant differences between the two groups.

Furthermore, a comparison of the total scores between the conventional palva's flap group and the newer proposed periosteal flap group revealed mean total scores of 13.67 ± 1.669 and 17.90 ± 0.447 , respectively. This difference in total scores between the groups was statistically significant (*t*: -17.306, *df*: 59, *p* = 0.000).

Table 4 The comparison between the two groups taking into account the various variable in the proposed scoring

Parameter	Scores	Conventional palva's flap (no. of patients: 51)	Newer proposed periosteal flap (no. of patients: 39)	Comparison statistic between the techniques	p-value
1 Surgical exposure	4 3 2 1	51	39		1
2 Ease of working after exposure	4 3 2 1	49	39	Chi-square: 1.564, df 1	0.211
3 Emissary vein injury	Yes (0) No (2)	26 25	39	Chi-square: 27.960 df: 1	0.000
4 Ease of closure of wound after device fixation	4 3 2 1	51	39	Chi-square: 90.000, df 1	0.000
5 Immediate complications (within 24 h)	Yes (0) No (2)	2 49	2 37	Chi-square: 0.076, df 1	0.783
6 Delayed complications	Yes (0) No (2)	3 48	39	Chi-square: 2.373, df 1	0.123
Total mean score		13.67 ± 1.669	17.90 ± 0.447	t: -17.306, df: 59	0.000

Table 5 Surgical site complication status comparison between flap techniques

Surgical site status	Type of flap		Total
	Conventional flap	Newer proposed flap	
No surgical site complication	46	37	83
Minor surgical site complication	2	2	4
Major surgical site complication	3	0	3
Total	51	39	90

On comparison between the groups, the differences in rate of surgical site complications were not statistically significant (chi-square: 2.419, df 2, and $p=0.298$) (Table 6)

Table 6 Chi-square tests

	Value	df	Asymp. sig. (2-sided)
Pearson chi-square	2.419	2	0.298
Likelihood ratio	3.532	2	0.171
Linear by linear association	1.473	1	0.225
N of valid cases	90		

In terms of complications related to the flaps, the novel flap group exhibited no major complications, while three patients in the palva flap group experienced flap complications necessitating surgical intervention. Specifically, two patients in the palva flap group required preoperative repair of flap tears using temporoparietal fascia flap. Nonetheless, the difference in flap-related complications between the groups did not reach statistical significance on the chi-square test ($p=0.289$) (Table 5). Additionally, two cases in the palva flap group displayed minor skin discoloration, which resolved over time.

These findings highlight the potential advantages of the novel periosteal flap technique, showcasing improved surgical outcomes with reduced complications compared to the conventional palva flap approach. The novel flap technique demonstrated superior scores in various parameters, signifying enhanced surgical performance and postoperative recovery. The absence of major complications in the novel flap group further reinforces its safety and efficacy, presenting a promising avenue for optimizing cochlear implantation procedures.

Discussion

Cochlear implantation has been a well-established procedure for over four decades, and despite continuous efforts by surgeons to enhance safety, complications continue to occur. Reported frequencies of major complications after cochlear implantation range from 1.08 to 8.2% [8, 9]. Surgeons have introduced various techniques for raising periosteal flaps to minimize procedure time, ensure safety, and provide adequate coverage for the receiver stimulator unit [5–7, 11].

Complications related to skin flaps after cochlear implantation are often associated with inflammation and soft tissue infection surrounding the device. Major flap complications require surgical intervention, while minor complications can often resolve spontaneously and be managed conservatively. A well-vascularized and tension-free flap is of paramount importance in avoiding flap-related complications [12, 13].

The design of both the skin flap and periosteal flap plays a crucial role in minimizing postoperative complications. The periosteal flap should have sufficient blood supply, appropriate width to cover the device, and be free of tension. Repeated manipulation to cover the device can lead to devascularization, resulting in flap necrosis and infection [12, 13].

The need for improved flap techniques led to the development of the novel periosteal flap. Prior to its introduction, the palva flap was commonly utilized at our center until May 2019. However, the thinness of the palva flap in very young children posed challenges and often led to flap tears requiring additional vascularized flaps, such as the temporoparietal flap, to achieve adequate device coverage [1].

Building on the success of a previously reported novel periosteal flap technique [1], this study further examined the efficacy of the same flap in an additional 39 patients who underwent cochlear implant surgery over a 1-year period. These patients were compared to a group of patients who had cochlear implantation using the standard palva flap between 2017 and 2019. The comparative analysis revealed a reduced incidence of emissary vein injury and easier wound closure after device fixation in the novel periosteal flap group, which was statistically significant ($p=0.000$). Furthermore, the mean total scores were higher in the novel periosteal group, indicating enhanced outcomes.

This novel periosteal flap boasts several advantages over palva flap, including its robust nature and larger anterior flap that extends more posteriorly to cover the implanted device (Fig. 1). The branches of posterior auricular artery, namely, the auricular and occipital branches form the major blood supply for this flap. The closure of the periosteal flap posteriorly is situated at a

considerable distance away from the skin incision, reducing edema, dead space, and the risk of vascular compromise (Fig. 2). Additionally, the flap's easy raising with minimal tension during device coverage and avoidance of the emissary vein further contribute to its potential in reducing flap complications.

One notable advantage of our flap is its ease of raising without tension while covering the device. Additionally, the flap offers another benefit by avoiding the emissary vein, which is not encountered as the incision to raise the flap is situated more anteriorly. In contrast, the palva flap has the potential to injure the emissary vein due to the incision being located over this area.

Conclusion

In conclusion, the surgical audit of 39 cochlear implantation cases utilizing the novel periosteal flap showcases its clear superiority over the palva flap. The new flap is quicker, well-vascularized, and sturdier, ensuring optimal device coverage with minimal complications. Its potential advantages can be further validated at other centers, reinforcing the benefits of this straightforward periosteal flap.

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Authors' contributions

NKP was involved in collection of data, literature search, writing—original draft, surgeries, and patient follow-up and was a corresponding author. KK was involved in data preparation, analysis, review of the final draft, and submission of manuscript. SKP was involved in data analysis, manuscript preparation, and review. All authors have read and approved the manuscript.

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Availability of data and materials

The data collected are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

All procedures performed in studies involving human participants were by the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Ethical approval was obtained from the institutional ethical committee, PGIMER. (Reference No: IECINT/2022/Study-482). Informed written consent to participate in the study and consent for surgery was provided by all the parents or legal guardians of the children who were included in the study.

Consent for publication

Patient's parents signed informed consent regarding publishing their data and photographs.

Competing interests

The authors declare that they have no competing interests.

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