Cochlear Implantation in Pediatric Patients: Comparison of Limited-Incision and Standard Cochlear Implantation

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Abstract Today, cochlear implantation has become the standard procedure for rehabilitation of people with impaired sensory neural hearing. This procedure can be done through different techniques. The present study aimed to compare the standard technique (ST) with creation of “C” incision into the scalp with suture fixation and limited-incision technique (LIT) with creation of subperiosteal pocket without any fixation. The outcomes included operative time and complications. This retrospective study was conducted on 343 consecutive cochlear implantations. The patients received cochlear implants at our institution between 2004 and 2011. The complications were identified as “minor” or “major”. All the complications and operation times were assessed for the two surgical techniques. The overall rates of complications were 4.4 % (11 out of 252) and 2.2 % (2 out of 91) for ST and LIT, respectively. The results revealed no significant difference between the two fixation techniques regarding the complications. The mean operation time was 150 ± 23.7 and 133 ± 23.12 min in ST and LIT, respectively, and the difference was statistically significant. Both ST and LIT are safe techniques with a relatively low complication rate. However, ST can be effectively replaced by LIT because of its shorter operative time.

Keywords Cochlear implant · Complication · Standard technique · Subperiosteal pocket technique

Introduction

Cochlear implantation (CI) is a worldwide and rather safe technique used for auditory rehabilitation [1, 2]. The number of CIs has increased dramatically during the last decade [3]. On the other hand, the risks of complications associated with all major surgeries can occur in CI surgery, especially in the Standard Technique (ST) operations. ST for CI involves large skin incisions and widespread invasion to soft tissue with large incisions and drilling of bony structures. These large manipulations could in turn lead to postoperative complications, such as devascularization, that resulted in hematoma and seroma formation as well as flap necrosis and infection [4–6]. The limited-incision technique (LIT), on the other hand, involves smaller incisions and tissue flaps, including no well or tie-down sutures at all [7–11]. This CI technique involves small soft tissue flaps and a tight subperiosteal pocket for the device. Nonetheless, it is important that both patients and practitioners be aware of the advantages and disadvantages of each surgery technique, including how many of the complications can be prevented by proper implant fixation during surgery. Overall, a large spectrum of surgical methods is available and more studies are needed to compare the gains and limitations of different surgical techniques. The present study aims to compare LIT and ST with respect to operative time and complications in pediatric patients.

Materials and Methods

This retrospective analysis of 343 consecutive CIs was performed in one of the largest referral hospitals in Iran between April 2004 and March 2011. The indication for CI

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was based on international recommendations [12]. The ST involved a large “C” incision into the scalp (~8–10 cm) and used intraosseous suture ligature. In other words, in this technique, the internal receiver-stimulator was fixed into a socket drilled on the calvarial bone. LIT, on the other hand, involved a 2.5–3 cm post-auricular incision for creation of subperiosteal pocket, the internal receiver-stimulator was fixed under this pocket, and drilling was not necessary (Fig. 1). The patients were monthly visited during the first year and every 6 months during the second year after the implantation. The complications were classified into minor and major categories, and included (1) device failure, (2) implant displacement, and (3) infection.

The data in the CI database were collected by an ear specialist and a research coordinator at the hospital. Then, the mean operation time was also assessed for the two surgical techniques. It should be noted that all the patients were fitted with the Nucleus (Cochlear Limited, Australia) CI.

Statistical Analysis

The data were expressed as mean $\pm$ standard deviation. The operation times were compared using Mann–Whitney test, while the complications were compared through Chi square test.

P value <0.05 was considered as statistically significant. All the analyses were carried out using the SPSS statistical software, version 18.0 (SPSS Inc.).

Results

Age at the time of initial surgery ranged from 12 months to 16 years (Mean $\pm$ S.D: 6.97 ± 1.89) and 12 months to 13 years (Mean $\pm$ S.D: 4.1 ± 1.97) in ST and LIT groups, respectively. The overall rates of complications were 4.4 % (11 out of 252) and 2.2 % (2 out of 91) in ST and LIT, respectively. The results revealed no significant difference between the two fixation techniques regarding the overall rates of complications ($P > 0.05$). Device failure occurred in 1.6 % of the patients undergoing ST operation that required explantation and reimplantation, while no complications were detected in those who underwent LIT operation. Besides, implant displacement occurred in 0.8 and 1.1 % of the patients undergoing ST and LIT operations, respectively. In addition, wound infection occurred in 2 and 1.1 % of the patients who underwent ST and LIT operations, respectively (Table 1). However, no significant difference was found between the two techniques regarding the 3 types of complications ($P > 0.05$).

The operation time ranged from 75 to 225 min (Mean $\pm$ S.D: 150 ± 23.7) in ST and from 90 to 210 min

(Mean $\pm$ S.D: 133 ± 23.12) in LIT. The operation time in LIT was significantly shorter compared to ST ($P < 0.05$).

Discussion

Using ST for CI can cause multiple complications, such as tissue devascularization, postoperative edema, and increased risk of infection and tissue necrosis [7, 8]. Nowadays, some techniques, such as LIT, involving small incisions have been developed in order to disrupt a lesser amount of the soft tissue blood supply, decrease the amount of created dead space [8, 9], and reduce the operative time [7–10].

In addition, the risk of dural injury and CSF leakage is present in ST when a bony structure is drilled. LIT, however, reduces this risk by avoiding bone drilling.

The results of this study revealed 2 types of complications, namely major and minor, in the patients. The major complications included those requiring additional hospitalization for a new treatment, such as explantation of the device, or causing a significant medical problem, such as leading to any degree of facial paralysis. Minor complications, on the other hand, were those treated spontaneously with conventional treatment, local care, and/or medication alone [4, 13, 14].

In this study, device failure and implant displacement were considered as major complications, while wound infection was considered as minor complication.

In 2004, Green et al. reported the rate of minor complications to be 7–37 % and that of major complications to range from 3 to 13.7 % [15]. In the other studies, the overall incidence rates of CI complications were reported as 13.6 % (4.4 % major and 8.8 % minor) [16], 18 % (2.3 % major and 16 % minor) [17], and 16 % (3.2 % major and 5.6 % minor) [3]. In our series, the overall rate of CI complications was 3.8 %. Besides, the rate of major complications (2.1 %) was lower than that found in the previous studies. Moreover, the overall rate of infections reported in the previous studies ranged from 1.7 to 16.6 % [3, 18, 19]. In our survey also, the rate of infection as a minor complication was 1.7 %.

The overall complication rate was 4.4 % in ST and 2.2 % in LIT, but the difference was not statistically significant. Similarly, Prager et al. [20] demonstrated no obvious differences between the two groups regarding the overall complications. Thus, they suggested that in comparison to standard CI, using a small incision without fixation was an appropriate and preferred technique because of decreasing the soft tissue incision and no well-drilling.

In the same line, Stratigouleas et al. [8] mentioned the advantages of LIT to be less dissection and postoperative edema, less venous stasis, decreased risk of pressure

Fig. 1 **a** ST involved a large “C” incision into the scalp (~8–10 cm) and used intraosseous suture ligature. **b** LIT involved a 2.5–3 cm post-auricular incision for creation of subperiosteal pocket, the internal

receiver-stimulator was fixed under this pocket, and drilling was not necessary. (Retrieved from <http://cdn.intechopen.com/pdfs-wm/36340.pdf> by Tange RA.)

Table 1 Frequency of the complications in the patients undergoing ST and LIT

	Device failure	Implant displacement	Wound infection	Total
Patients undergoing ST n (%)	4 (1.6)	2 (0.8)	5 (2)	11 (4.4)
Patients undergoing LIT n (%)	0 (0)	1 (1.1)	1 (1.1)	2 (2.2)
Total n (%)	4 (1.2)	3 (0.9)	6 (1.7)	13 (3.8)

necrosis on the skin, and earlier mapping times (typically occurring on postoperative day) compared to ST. Likewise, Mann and Gosepath [21] used the similar technique and reported no postoperative complications.

In a previous study, Mack et al. [22] used a small 5–6 cm postauricular incision and the receiver/stimulator was accommodated with elevation of a subperiosteal plane. The main advantages claimed by the authors included no need for shaving of hair, lack of a visible scar, and no need to fix the implant with non-absorbable sutures. Also, they found no wound infection and no skin flap complications in the patients. Hence, LIT appears to allow for an efficient and minimally invasive approach and a small wound in comparison to the ST. It may also result in fewer wound-related complications [23–25].

Davids et al. [10] concluded that device fixation was a safe method in pediatric patients undergoing CI, especially considering the thinner soft tissue envelope in children compared to adults. The increased risk of displacement due to frequent falls in the patients younger than 18 months should be noted, as well [26]. In our study, only one LIT patient experienced implant displacement (1/91 or 1.1 %).

The risk of displacement with originate from head trauma appears to be quite low. Cohen and Hoffman [4] reported the rate of electrode migration to be 1.2 % (from

nearly 5,000 implants). In addition, Prager et al. [20] indicated that 2.8 % (2/73) of the pediatric patients undergoing minimal access CI had implant displacement. Whether this complication could have been avoided with fixation is unknown.

In the current study, the mean operative time was lower in the LIT group compared to the ST group (133 ± 23.12 vs. 150 ± 23.7 min, $P < 0.0001$). Similar results were also obtained by Prager et al. [20] and Guldiken et al. [23]. Nonetheless, Guldiken et al. [23] reported the mean operative time to be 73.4 ± 17.8 in the subperiosteal group and 105.5 ± 17.8 min. in the ST group. These measures were respectively reported as 149.5 ± 28 and 200 ± 45 min in the study by Prager et al. [20].

The notable differences in the mean operative times reported in these three studies may result from different trademarks of the devices used in each study. Device size and type might have impacted the operative times, as well. This might also be due to the difference in the surgeons' experiences and skills.

The limitations of the present study are the same as those of any retrospective chart review. Moreover, the surgeon's skills and efficiency along with the operating room staff's efficiency were the invisible factors that could have influenced the results. Finally, device size and type

might have affected the success of the LIT and comparison of different devices in our study does not substantiate.

In Conclusion, Because of the shorter operative times and the minimal invasive manipulations of LIT in comparison to ST, it can be safely and effectively used in CI, especially in pediatric CI operations. Many studies have described less invasive CI techniques, but few have described a technique without suture tie-down. Of course, further studies with long-term follow-ups are necessary to investigate the complication rates of LIT.

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Conflict of interest None declared.

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