

# Normative eSRT Value among MED-EL Pediatric Population in Indonesia

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# Abstract

Introduction: Early stimulation of the auditory sense is essential for the development of language and speech. In children with a cochlear implant, the most common issue is whether the hearing has been optimized or not, as they are still unable to provide reliable feedback regarding their hearing ability. Thus, electrically evoked stapedius reflex threshold (ESRT) based fitting has been used as one of the available methods in programming a cochlear implant (CI) audio processor. As eSRT is an objective test, patient cooperation was not needed making it especially beneficial for children with CI who have limitations in providing feedback. Now that eSRT has been applied commonly almost worldwide, the goal of this study is to determine the normative value of eSRT among the pediatric population in Indonesia. Methods: A total of 32 pediatric CI users in the age range 3 - 11 years implanted with Med-El cochlear implant were included in this study. ESRT was performed during follow-up mapping between September 2021 and January 2022 in the Med-El Indonesia hearing center. Results: The result of the present study showed an average normative value of 20.55 qus. This finding is consistent with the values obtained in previous studies. Conclusion: The result found can be used as a valuable indicator of average optimised MCL among the pediatric population.

# **Keywords**

Cochlear Implant, eSRT, Mapping, Acoustic Reflex

# **1. Introduction**

Over the past thirty years, the criteria of cochlear implant candidacies have been expanded, including very young age and children with multi-issue. With broader criteria, a number of issues have arisen, one of them being to provide an accurate fitting of the cochlear implant. It is widely known that the appropriate fitting is one of the main success factors in a cochlear implant. The goal of the fitting process is to provide a cochlear implant recipient with the ability to perceive the desired range of acoustic signals, known as dynamic range. The dynamic range is accomplished by determining the minimum and maximum stimulation levels, which are mostly based on subjective measurements of thresholds (THR levels) and the maximum comfortable level (MCL levels) during the fitting process. Thus, a cochlear implant performs optimally when THR and MCL levels are set accurately, and MCL loudness is balanced across electrodes [1]. These psychoelectric parameters are obtained in order to make a normal conversational speech as loud and clear as possible, soft sounds distinguishable, and loud sounds that are comfortably loud. Therefore, the map is adjusted individually according to the necessary electrical level of stimulation. In the adult, these two parameters are usually performed through a psychophysics judgment. The user will be given a loudness scale to judge the presented stimulus at each electrode until the loudest tolerable stimulation is achieved. However, it is typically difficult to determine comfortable auditory levels in cochlear implant patients, particularly in very young, handicapped, and prelingually deaf children. This population, due to limitation of hearing experience, have a lack of language production and inability to cooperate in formal tasks, making it difficult for them to respond reliably to the given stimulus during a fitting process, so they are often exposed to overstimulation or under-stimulation which can give a traumatic effect as well as a negative impact on amplitude cues and spectral information important for phoneme identification, resulted in gualitative differences and significantly poorer speech perception [2]. This, in turn, may result in a delay in speech and language development. Hence, the necessity for objective measures will be useful in determining the MCL. Several objective electrophysiological techniques have been used to complete behavioral assessments in CI recipients. One of the most frequently used tests is eCAP (electrically compound action potential) and eSRT (electrically stapedius reflex thresholds). However, among those two, eSRT shows the strongest correlation with behavioral MCL. The stapedius reflex is defined as a contraction of the middle ear muscles caused by an intense acoustic stimulus. The acoustic reflex is defined as the lowest intensity of sound that causes the smallest measurable change in the middle ear normally between 70 and 90 dBSPL. In cochlear implant users, the reflex is elicited through electrical stimulation. Many researchers have demonstrated that eSRT is the most reliable objective measurement as it is highly correlated with behavioral MCL [3] [4] [5].

This study aimed to know the average normative eSRT value among the pediatric population using Med-El in Indonesia.

# 2. Material and Methods

## 2.1. Subjects

In total, thirty-two pediatric subjects provided the data used for this study. All implanted with Med-El device. Full electrode insertion was achieved for all sub-

jects and at least 6 months of experience with the cochlear implant.

## 2.2. Methodology

All data will be retrieved as follows; subjects who attend follow-up mapping in Med-El Indonesia hearing center from September 2021 and January 2022. Patient history reviewed includes etiology of hearing loss, the use of a hearing aid and intraoperative report.

## 2.3. Method of Sampling

The participants of this study will be selected among patients in Med-El Indonesia who meet the inclusion and exclusion criteria stated. Thus, the sampling method that will be used in this study is convenience sampling. Inclusion criteria are as follows: implanted with Med-El cochlear implants, age ranges from 3 to 11 years old, had normal cochlea, tympanometry shows type A tympanogram and no history of middle ear issue. Exclusion criteria are as follows: abnormal middle ear function, abnormal cochlea, and retro cochlear pathology.

## 2.4. Instruments

Otoscope, GSI Tympstar Pro middle ear analyzer, maestro system software 9.04, max programming interface provided by Med-El and a notebook compatible with the software.

#### 2.5. Preparations

Prior to the schedule, parents were informed that eSRT will be tested and the child needs passive cooperativeness or if it is impossible for the child to remind still, the test can be performed under natural sleep. During the session the measurement will start with otoscopy to confirm the external auditory canal is clear as well as to choose the suitable probe followed by a tympanometry test to confirm the status of the middle ear region.

## 2.6. Recording

A better ear indicates normal middle ear status will be selected. The latest maestro system software version 9.04 opened, and the patient's audio processor connected to the computer through the Max programming interface. Impedance field telemetry is always performed at the beginning of the test to exclude stimulation on non-functioning electrodes. However, the parameter on eSRT task was set to the stimulus burst duration at 300 ms, with 1000-ms gaps between bursts. All active electrodes will be stimulated. The level starts from the latest MCL used by the child. Charges on these electrodes were gradually increased until a reflex was elicited. Thresholds were established by decreasing and increasing charge levels in 3% increments around this level. The ESRT is considered absent when current levels exceeding the participant's tolerance failed to produce changes in admittance that were time-locked with the stimulus.

## 3. Results

This study included a total of thirty-two subjects with age range from 3 - 11 years old, 17 girls and 15 boys. Preoperative imaging evaluation showed normal cochleae for all patients and full insertion was achieved in all cases. Demographic for all subjects are provided in **Table 1**. Of 32 subjects, 6 subjects were excluded from the study. The first child has an earwax blockage in the external auditory canal, making tympanometry impossible to perform; the second child cried during the session and could not sleep preventing eSRT measurement, and no obvious reason for not obtainable response for the rest of the child.

From 26 subjects, 40 implanted ears were examined, and all active electrodes were tested. As shown in **Figure 1**, the lowest value was obtained at 12.30 qu and the highest at 36.17 qu.

 Table 1. Subject demographics.



Figure 1. eSRT value for 26 subjects (40 ears).

On electrode number  $1^{st}$  to  $6^{th}$  eSRT threshold was successfully obtained at 19.24 to 19.70 qus in all subjects. Electrode number  $7^{th}$  and  $8^{th}$  obtained at 20.76 to 21.22 qus in 25 subjects. Electrode number  $9^{th}$  and  $10^{th}$  obtained at 21.18 to 21.03 qus in 24 subjects. Number  $11^{th}$  reduce to 23 subjects at 22.10 qu and the last reduce to only 20 subjects at electrode number  $12^{th}$ ; threshold was obtained at 21.76 qu. (Table 2 & Table 3)

**Table 2.** The percentage of electrodes where the electrically evoked stapedial reflex threshold could be measured.

ESRT	Number of electrodes (n (%)
Measured	427 (67.13)
Non-measured	209 (32.87)

ESRT, electrically evoked stapedial reflex threshold.

Table 3. Mean and SD of electrically evoked stapedial reflex threshold.

Electrode number	Number of patients	ESRT
1	26	$19.24 \pm 4.82$
2	26	$19.62 \pm 5.32$
3	26	$19.82 \pm 4.81$
4	26	$18.99 \pm 4.38$
5	26	$19.70\pm4.78$
6	26	$21.20 \pm 5.58$
7	25	$20.76 \pm 4.86$
8	25	$21.22 \pm 4.24$
9	24	$21.18 \pm 3.69$
10	24	$21.03 \pm 4.35$
11	23	$22.10 \pm 5.46$
12	20	$21.76 \pm 5.39$

# 4. Discussion

It is widely known that early auditory stimulation is profoundly important to developing language and speech in children. Thus, to maximize the benefits of early implantation, an accurate speech processor program must be delivered quickly. Programming a cochlear implant is accomplished by determining the dynamic range of each electrode [6]. This dynamic range consists of a MCL (maximum comfortable level) as an upper limit and THR (threshold) as a lower limit [7]. According to Stephan and Welzl-Müller, a cochlear implant performs optimally when THR and MCL levels are set accurately and MCL loudness is balanced across electrodes [1]. However, Smoorenburg *et al.* discovered that MCL level and loudness balancing have a greater impact on patient performance than THR level. Lowering THR levels by 25 to 30 current units has no negative effects on speech perception scores but, a change in the slope of MCL values may have a negative impact on speech comprehension [8].

Dawson *et al.* hypothesized that insufficient and/or unbalanced MCL levels would have a negative impact on amplitude cues and spectral information important for phoneme identification. MCL levels were systematically varied to examine the potential impact on speech performance. Unbalanced MCLs resulted in qualitative differences and significantly poorer speech perception. Subjects described the sound quality as rough, with echoes and dominant sounds. In the unbalanced condition, mean speech performance was significantly worse for both sentence and phoneme stimuli [2].

Also, Saoji *et al.* found there is a significant derivation of speech perception as the effect of implant use exceeding the compliance limit [9].

However, obtaining behavioral MCL in children is a difficult task even for an experienced audiologist. So, an objective measurement has been found to be an effective method for programming CI in children and has been used frequently.

Jerger *et al.* were the first to demonstrate that the stapedius reflex can be elicited by electrical stimulation of a CI [10]. A later study has reported high correlations between behavioral MCL and ESRT levels in both adult and pediatric CI users, with a r value of around 0.9, validating the use of ESRTs to generate programs. Lorens *et al.* found a correlation coefficient of 0.789 between ESRT thresholds and MCLs in a pediatric population [4]. Similarly, Kosaner *et al.*, Stephan and Welzl-Müller, and Walkowiak *et al.* found high r values between behavioral MCLs and ESRT thresholds ranging from 0.75 to 0.92 [1] [3] [5].

In the present study, eSRT as a based map in programming children is also being evaluated. With the higher incidence of middle ear issue in children, it is possible that reflexes will be measurable in a smaller percentage of children than in adults. Spivak and Chute have reported that reflexes were absent in 30% of the pediatric patients they studied [11]. Also, Asal *et al.* reported that total of 312 electrodes were tested, eSRT measurement could be performed on 213 electrodes (68%) and on the remaining 99 electrodes (31%) eSRT is non-measurable. Those findings were consistent with the 32.87% non-obtainable response in the current study [12].

One major reason for not finding reflexes was unresolvable middle-ear problems. In a few cases, the reason for not eliciting a reflex was an inability to generate sufficient charge in the presence of ossification and nonauditory stimulation. This is confirmed by the child's lower than normal implant sound-field thresholds. Many children have no obvious reason for not being able to record a reflex. One reason could be that the reflex is difficult to separate from artifacts. Spontaneous movement of the tympanic membrane in children with flaccid membranes can make it difficult to distinguish the reflex from background noise [3].

The CI recipients in this study have a mean eSRT of 20.55 qu (19.24 to 22.10 qu). This finding is consistent with the one conducted by Baysal *et al.* which obtained the threshold between 20.08 to 23.50 qu post operatively. In his study, 65 children implanted with Med-El, the eSRT threshold obtained between 36.19 to 61.55 qu intraoperatively. A month after surgery, with the same subjects, he re-

peated the measurement and obtained that the value significantly decreased between 20.08 to 23.50 qu. The reason for higher values explained in the literature, the effects of volatile anesthetic agents have explained the greater thresholds observed in the operating room (OR). No muscle relaxants were used during the operation, and sevoflurane was used as an anesthetic agent, which could explain why the thresholds were higher in the OR. He concluded that intraoperative eSRT is unlikely to be used as a guide to mapping electrode in children who cannot provide behavioral feedback [13].

However, the results of the present study were found to be slightly higher than the one performed by Walkowiak *et al.* They conducted a study on 14 pediatric users and 13 post lingual adults. In 14 pediatric Med-El subjects who had at least 3 months of experience using the device, he obtained an eSRT threshold between 16.8 to 21.0 qu. While in adults, he found the threshold between 19.5 to 20.9 qu. The main goal of the study is to compare the eCAP threshold with eSRT in pediatric and adult users. The strongest relationship was found between MCL and eSR threshold where the r varied from 0.8 to 0.83, depending on the electrode testing. They concluded that there are no statistical differences between adults and children in terms of mean eCAP and eSR threshold [14].

Also, Çiprut and Adıgül have reported an eSRT mean value for 18 subjects implanted with Med-El devices which were 20 to 26 qu [15]. The mean eSRT threshold of 52 experienced pediatric patient implanted with Med-El CIs was determined by Kosaner *et al.* as 23.68 qu [16].

On the contrary, Asal *et al.* found that the mean eSRT threshold was between 27.19 and 31.94 qu. This value is greater compared with the present study. They also reported that from the 20 subjects tested, the incidence of obtainable eSRT is reduced at high frequency [12]. That finding is similar to the current study, which is also reduced at basal electrodes.

Among all the studies explained above, a trend toward higher thresholds was found in the basal area, compared to the more apical electrode. Nevertheless, Allum *et al.* revealed that the eSRT underestimates C levels at apical positions and overestimates C levels at basal portions, and they proposed that this phenomenon occurs due to the modiolus hugging electrode mechanism. Apart from the higher current ranges required in this region to elicit a reflex, this would presumably result in less focused stimulation of auditory nerve endings in the basal region [17]. However, Med-El CIs used in this study did not have a modiolus-hugging mechanism. Interestingly, Degen *et al.* compared electrode effect to modiolus distance on electrophysiological and psychophysical parameters. They found that electrode position has a significant effect on both electrophysiological and psychophysical parameters, while impedances and eSRT are not impacted [18].

Despite the fact that many studies have been conducted regarding the effectiveness of eSRT and its application in audiological field, the main goal of the present study was focused to investigate the mean value of eSRT among pediatric population and to use it as a fitting guideline to optimize the MCL. The result was successfully obtained at an average 20.55 qus and it is consistent with the previous study reviewed in the literature. However, a limitation of the current study is that we are unable to repeat the measurement of non-obtainable subjects due to several technical factors such as a patient living on a different island, so they only come to the clinic for an annual check. As they are experienced users and performing well with the current map, it was not considered that these were urgent matters to repeat in the near future.

## **5.** Conclusion

With the current study, the electrical stapedius reflex threshold can be successfully measured as 67.13% in the pediatric population using Med-El CIs. The reason for 32.87% non-obtainable response is due to an external auditory canal block, insufficient cooperativeness, and no obvious reason for not having reflex. The mean threshold was found at 20.55 (19.24 to 22.10 qus). The eSR threshold tends to be higher at high frequencies compared to low frequencies. These thresholds appear to be consistent with previous studies. Research shows that eSRT can be used both intraoperative and postoperative. However, the intraoperative eSRT threshold was found to be higher compared to postoperative. Therefore, the value is unlikely to be used as a guideline to map electrodes in children who cannot provide behavioral feedback. As an objective method, eSRT proves to be a reliable and useful tool for programming uncooperative and difficult-to-test young patients as it is having high correlation with behavioral maps.

## **Conflicts of Interest**

The author declares no conflicts of interest regarding the publication of this paper.

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