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Preliminary Results of Cochlear Implantation in Underdeveloped Countries: The Experience of Cameroon

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Abstract

Introduction: Deafness, is the most common neurosensory deficit in humans. The origins can be diverse: congenital or acquired and sometimes of an etiology that is difficult to specify. The main risk is social exclusion. The advent of cochlear implants is a solution of choice for severe to profound sensorineural hearing loss. This innovative therapeutic modality is new to Cameroon, so we proposed to evaluate the preliminary results of cochlear implantation at the General Hospitals of Yaoundé and Douala, by addressing the epidemiological, clinical and paraclinical, surgical, and prosthetic aspects. **Methodology:** We conducted a descriptive and prospective cross-sectional study over a period of two years and eight months, from January 2019 to 31 August 2021. The study sites were: the general hospitals of Yaounde and Douala, as well as the private practices of speech therapists in the said cities. We collected socio-demographic, clinical, paraclinical variables and data on surgical, prosthetic and speech therapy management which were processed. **Results:** We recruited 15 cochlear implant patients, one adult and 14 children. The sex ratio was 1.14 in favour of girls, the average age of the child population was 4.9 years and one subject was 57 years old. These children were mostly in school (85.7%) and mostly (86.7%) living in urban areas. The average period of sound depri-

vation was 3.9 years. The deafness of the children was 100% prelingual and the acquired cause was evoked in front of the risk factors (prematurity, low birth weight, neonatal asphyxia, jaundice, meningitis, neuromalaria) for 57.7% of them. The adult deafness was postlingual and post-traumatic. The associated clinical conditions found in 4 (26.8%) of the patients were an ocular refraction disorder, a chronic otitis media sequelae, cerebral palsy and minor head trauma injuries. There was no syndromic or malformative picture. The deafness was bilateral in all cases, asymmetric in 22.2% of cases and severe to profound sensorineural. The threshold of the deafness was deep in 78.6% of cases, with a more marked involvement on the right. Imaging studies (MRI and CT scans of the cranium, brain and rock) carried out in our series showed abnormalities in 4 (26.7%) of the children, but none of these abnormalities were an absolute contraindication to implantation. The surgical management was done with oticon® Neuro ZTI implants. Implantations were unilateral and mostly right, with one case of stenosis of the round window recess observed. The postoperative course was simple for 92.8% of patients. One case of superinfection of the surgical wound. The activations were performed within four to five weeks after surgery and the implant was functional in fourteen patients and dysfunction was observed in one patient. **Conclusion:** The cochlear implant is an effective solution in the fight against severe to profound sensorineural deafness. The diffusion of this therapeutic tool in our environment is still hampered by the youth of the teams, the lack of equipment and the insufficient financial means.

Keywords

Cochlear Implants, Deafness, Cameroon

1. Introduction

According to the "Centre d'Information sur la Surdité et l'Implant Cochléaire" (CISIC), one child in 700 to 1000 is born profoundly or severely deaf, making deafness the most common neurosensory deficit in humans. The etiologies are diverse: congenital (genetic in almost half of cases) or acquired (infectious, drug-induced and traumatic) and sometimes of an etiology that is difficult to specify [1] [2]. Severe or profound deafness constitutes a handicap that carries the risk of social exclusion, particularly when it occurs before language acquisition. Early treatment is imperative. In Western countries, the management of severe and profound deafness over the past 30 years has benefited greatly from the technological innovation of the cochlear implant (CI) [3] [4]. In Cameroon, this surgery is in its early stages. Cameroon, thanks to international cooperation, has benefited since 2018 from cochlear implant missions within the framework of the activities of the Association for the Fight against Deeafness in Cameroon (AFDC). Thus, several patients have been able to benefit from a cochlear implant. It therefore seemed useful to us to evaluate our activity. We proposed to

present the short and medium term results of patients who have benefited from cochlear implantation in the General Hospitals of Yaounde and Douala, both on the epidemiological, clinical and paraclinical, surgical and prosthetic levels.

2. Objectives

The general objective was to present the preliminary results of the ongoing cochlear implant programme in Cameroon. Specifically, the aim was to present the epidemiological profile of the patients, to examine the clinical and paraclinical profile of the patients, to describe the therapeutic modalities proposed to the patients, to evaluate the immediate and medium-term results on the surgical and prosthetic level of the patients.

3. Methodology

We conducted a descriptive and prospective cross-sectional study over a period of two years and eight months, from January 2019 to 31 August 2021. The study sites were the general hospitals of Yaounde and Douala, as well as private speech and language therapy practices in the said cities.

The source population consisted of patients with severe bilateral sensorineural hearing loss, profound hearing loss or cophosis. The target population consisted of patients who had been selected and were eligible for cochlear implant surgery after a pre-implant assessment validated by an expert committee. The pre-implant assessment included: a CT scan of the rocks, a brain magnetic resonance imaging, a fundus, a speech and language assessment, a psychological assessment, and a parental survey to assess parental attendance at post-implant speech and language therapy visits. The inclusion criteria were: all patients with severe, profound or cophotic hearing loss, with a validated pre-implant assessment, who had received a cochlear implant as part of the implant programme and had post-implant speech therapy follow-up. Exclusion criteria, we excluded patients who refused to participate in the study, and patients who were managed outside our study sites.

Sampling was consecutive and exhaustive of patients selected and operated on during the cochlear implant programme from January 2019 to May 2021.

We collected socio-demographic, clinical, paraclinical, surgical, prosthetic and other data. A questionnaire was complited to collect the data. The data were processed by statistical analysis using CSpro 7.3 and Microsoft Excell 2016 software. The results expressed in numbers, percentage, mean and standard deviation were illustrated by tables and graphs.

4. Results

We recruited 15 patients in total, 14 children and one adult. They were implanted between January 2019 and May 2021 in the General Hospitals of Douala (nine patients) and Yaoundé (six patients). All of them received implants of the brand OTICON®.

4.1. Epidemiological Profile of Patients

4.1.1. Sex

Our sample consisted of eight male and seven female patients, giving a sex ratio of 1.14.

4.1.2. Age

The ages of the children at the time of recruitment ranged from one and a half to eight years with a mean age of 4.95 years. The adult patient was 57 years old. We divided the patients according to age at clinical suspicion, diagnosis and management. The average time from clinical suspicion to diagnosis was 1.9 years with an average age at diagnosis of 2.9 years; the average time from diagnosis to implantation was two years with an average age at cochlear implantation of 4.9 years. Figure 1 shows the distribution of children according to age of suspicion, diagnosis and implantation. The adult patient has not been represented in this figure.

From the ages at the time of clinical suspicion, diagnosis and management, we were able to calculate the average time to management and sound deprivation. The average time between diagnosis and management of the patients in our series was 1.9 years (min = 3 months; max = seven years), for a mean sound deprivation time of 3.9 years in children.

4.1.3. Socio-Demographic Data

In our series, 86.7% of the patients lived in urban areas. Of the children, 85.7% were in school. Schooling was provided in a traditional school for 58.3% and in a special school for 41.7%. The level of schooling was kindergarten for those in the classical school.

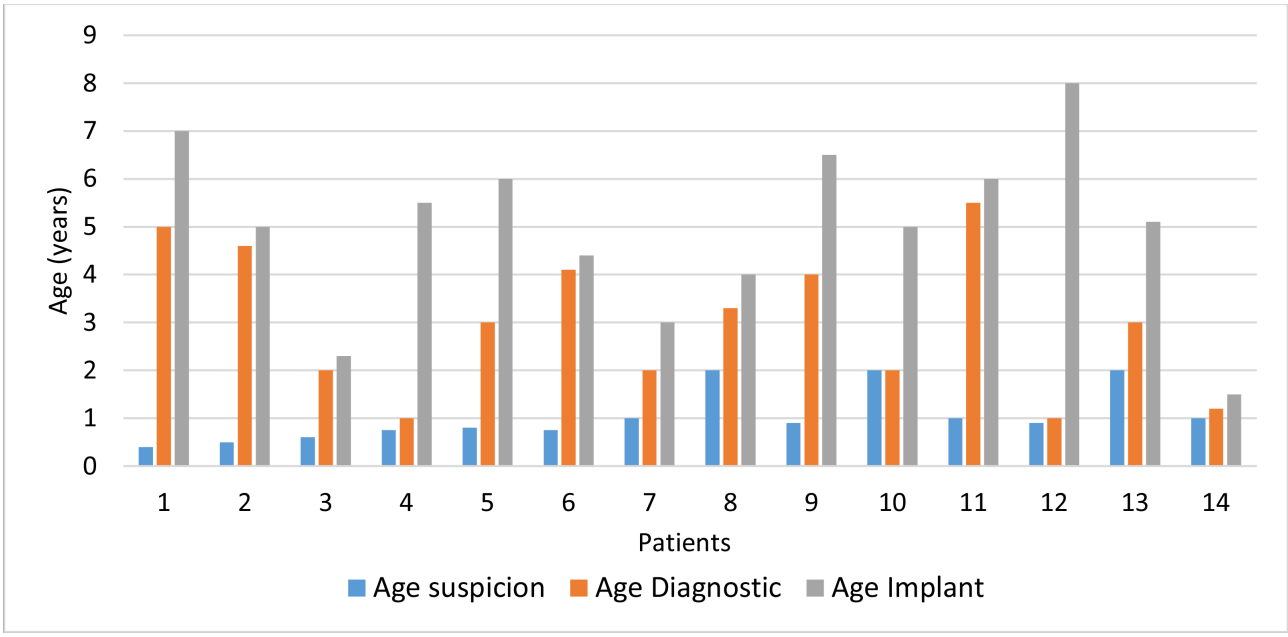

Figure 1. Distribution of children according to age of suspicion, diagnosis and implantation.

4.2. Clinical and Paraclinical Profile of Patients

4.2.1. Clinical Profile

Risk factors for acquired hearing loss were found in 57.1% of the child population. The most frequent risk factors were: low birth weight, neonatal asphyxia, foetal distress, prematurity, neonatal jaundice and infections (meningitis, rubella and severe malaria).

Deafness was suspected in 86.7% of the cases by the parents, due to language delay or lack of response to loud noises. One case was found incidentally during a routine consultation, and another appeared following a post-myocardial infarction head injury.

In 73% of the cases, deafness was suspected before the age of one.

Four conditions were associated with deafness: myopia, cerebral palsy, sequelae of chronic otitis media and head injury syndrome.

4.2.2. Paraclinical Profile

The hearing tests performed in our series were: evoked potential auditory (EPA) (93.3%), and tone or behavioural audiometry (64.3%). All patients underwent an imaging work-up including CT and MRI.

Subjective audiometry:

They were performed in nine patients. These included baseline pure tone audiometry in the only adult patient in our series and behavioural audiometry in the children. The average hearing losses (AHL) calculated for each patient and each ear are shown in Table 1. All patients were bilaterally affected. They were asymmetrical in two patients, *i.e.* 22.2% of the cases.

Objective audiometry

Otoacoustic emissions (OAE) were measured in seven children and the results showed that all seven subjects had no curves.

EPA was measured in 14 children and we found bilateral damage in all of them with asymmetry in two cases (14.3%). The evaluation by side showed 92.8% of profound deafness on the right and 78.6% on the left, Table 2 shows the results of the EPA measurements.

Table 1. Average hearing loss per ear.

Value of MHL*	Left ear (%)	Right ear (%)
Asymmetric hearing loss N = 2		
Severe hearing loss]70 - 90] dB	0 (0)	1(11.1)
Profound hearing loss 91 - 120 dB	2 (22.2)	0 (0)
Cophosis ≥ 120 dB	0 (0)	1 (11.1)
Symmetrical hearing loss N = 7		
Profound hearing loss]90 - 120[dB	5 (55.5)	5 (55.5)
Cophosis ≥ 120 dB	2 (22.2)	2 (22.2)

*MHL = moderate hearing loss.

Imaging assessment:

The imaging studies (craniocerebral and rock MRI and CT) performed in our series showed abnormalities in four patients (26.7%). The abnormalities found are shown in Table 3.

Pre-implantation speech therapy assessment:

All implanted children were previously assessed by speech and language therapy. The child's readiness for oral communication, but also the parents' motivation for verbal communication was assessed. Table 4 shows the results of the speech therapy assessment.

Table 2. Results of EPA measurements.

EPA thresholds	Left ear Number (%)	Right ear Number (%)
Asymmetric impairments (N = 2)		
Moderate: V-wave threshold: 40 - 69 dB	1 (7.1)	0
Severe: V-wave threshold: 71 - 95 dB	1 (7.1)	0
Profound > 95 dB	0	2 (14.3)
Symmetrical impairments (N = 12)		
Severe: V-wave threshold: 71 - 95 dB	1 (7.1)	1 (7.1)
Deep > 95 dB	11 (78.6)	11 (78.6)

Table 3. Description of abnormalities found on MRI and CT.

Anomalies found	Number N = 15	Percentage %
CT Scan		
Bilateral rock fracture	01	6.7
Round window anomaly	01	6.7
Non-progressive hydrocephalus	01	6.7
MRI		
Vascular-Nervous Conflict	01	6.7
Periventricular leukopathy	01	6.7

Table 4. Results of the speech and language assessment.

Variable	Workforce N = 14	Percentage %
Child's oral communication skills (N = 14)		
Present	13	92.9
Absent	1	7.1
Parents' motivation for the child's oral communication	14	100

4.3. Previous Treatments: Prosthetic Trial

Five of the patients in our series (35.7%) received a hearing aid. Only two had a prosthetic gain.

4.3.1. The Indications

The main elements that were considered for the indication of cochlear implantation in our series are shown in Table 5.

4.3.2. Therapeutic Profile

Cochlear implant surgery

The surgeries were performed by the same operator for all patients in our study, a foreign operator assisted by local teams.

The implantations were all unilateral. Thirteen implants were placed on the right and two on the left. The choice of the side to be implanted was determined by audiometric and radiological data; the ear with the greatest hearing loss was chosen and the radiological features directed the choice to the ear that presented the least risk for surgery. Figure 2 shows the surgical environment at the Yaounde General Hospital and Figure 3 shows the image of a cochleostomy performed in the same hospital.

The implants were all Oticon® brand, Neuro2 ZTI BTE type, with 20 electrodes.

Surgical assessment

The early postoperative course was simple in all patients. Discharge was allowed between the second and third postoperative day. The frequency of dressing was at an interval of five days.

Short-term postoperative follow-up (around the tenth postoperative day) was

Table 5. Indications for cochlear implantation in our population.

Variables	Workforce	Percentage (%)
Age		
Child < 5 years ± palatability	2	13.3
Children > 5 years with appetite	10	66.7
Children > 5 years with appetence and low prosthetic gain	2	13.3
Post-lingual adult	1	6.7
Audiometric and etiological indications		
Severe to profound bilateral symmetrical congenital sensorineural hearing loss	6	40
Severe to profound bilateral symmetrical sensorineural hearing loss	9	60
Imaging in favour of surgery	15	100
Speech and language assessment in favour of	15	100

Figure 2. The surgical environment at the Yaounde General Hospital.

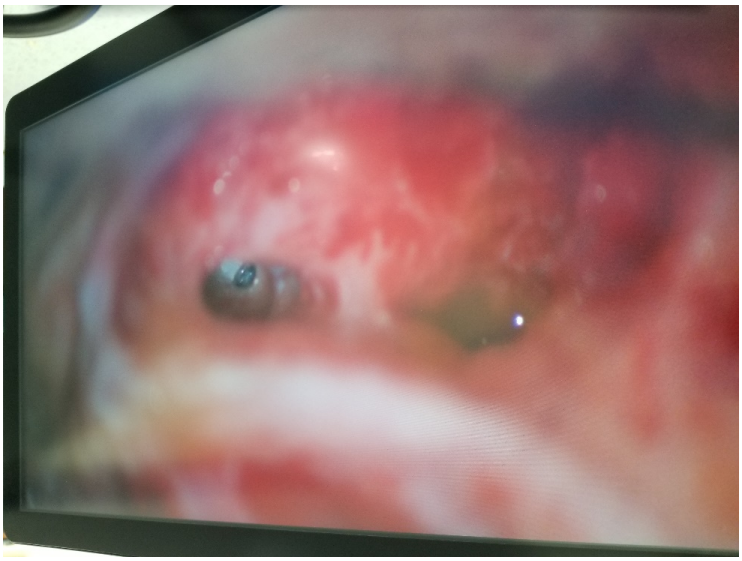

Figure 3. The image of a cochleostomy performed in the same hospital.

normal in 93.3% of cases (14 patients) and complicated in one patient by an infection of the surgical site which progressed favourably.

The control X-ray, Sternvers incidence, the day after surgery was performed in all patients and did not reveal any abnormality and the electrode holders were well wrapped in the cochlea turns.

Prothetic evaluation

- Activation time: The implants were activated within 4 and 5 weeks in 14 (92.9%) and one patient (7.1%) respectively. This represents a delay of one week in the activation of one of the implants. The patient with a surgical site

infection had to be activated one week later to achieve complete healing. All 20 electrodes were activated in 13 patients (92.8%) and 18 electrodes in one patient (7.1%).

- Thresholds: Activation was done by gradual digital stimulation of all electrodes in packs of 4 electrodes, up to a threshold where the patient was most comfortable. The comfort thresholds were variable from one individual to another.
- Frequency of adjustments: it was quarterly in our series and according to the post-implantation hindsight we found six patients who were on their first adjustment (implanted in May 2021), four who were on their third adjustment (implanted in 2020), one who was on his fourth adjustment (October 2019) and three who were on their sixth adjustment (January 2019).

Incidents:

- We identified four incidents (26.7%).
- Two failures of the external processor were reported (13.3%) after activation. These were resolved within one month at no additional cost to the patient by replacing the damaged parts.
- Two internal processor failures (13.3%) were reported: One at the time of activation in a child, with two non-functional electrodes (*i.e.* 10% of the electrodes) and in the adult subject post-activation, with 12 damaged electrodes (*i.e.* 60% of the electrodes) after one month of effective operation.

5. Discussion

The aim of our study was to present the preliminary results of the cochlear implant programme in Cameroon, based on the experience of the general hospitals of Yaounde and Douala.

5.1. Epidemiological Profile of Patients

During our study period, we recruited fifteen patients, all of Cameroonian nationality, who were implanted between January 2019 and August 2021 in the general hospitals of Douala (60%) and Yaounde (40%). The first year of the experiment had five patients (33.3%), and the number increased to 6 patients (40%) by the third year. Indeed, such numbers have not been found in the literature for other African countries in their early days of cochlear implantation. At the Mohammed IV University Hospital in Morocco, in three years (from June 2007 to June 2010), their first experiences involved three cases, Nigeria in its first experiences in 2005 had implanted only two patients on their territory, Gabon three cases in four years (since 2017). Only Senegal (14 patients implanted in 2018) and Ivory coast (12 patients implanted between December 2015 and February 2018) were close to the Cameroonian figures in terms of numbers at the first local cochlear implantation experience [5] [6] [7]. This could be explained by the strong mobilisation of AFDC with the awareness-raising and mass screening for deafness in schools undertaken since June 2019 and which continued in

March 2020 at the GHY. The AFDC has also invested in financial partnership agreements that have been able to subsidise through a major implant donation, thus offering 73% of the patients in our series the opportunity to have free of charge the recent generation Neuro2 ZTI cochlear implants from the firm Oticon® [8].

5.1.1. Gender

The predominance related to gender varies from one study to another without real significance. Thus, Hssaine *et al.* in their 2010 study in Morocco, could find a male prevalence and later in 2014 a female prevalence [6] [7]. C. Patron in 2006 in Quebec found a sex ratio of one [9].

5.1.2. Age

The age of our study population was very heterogeneous due to the age difference between the group of children and the adult subject, giving extremes of 1.5 to 58 years. The median was 2 years and the interquartile range was between 1 year 8 months and 4 years 3 months. The child population was thus predominantly represented (93.3%) and the toddler age group was the most represented in our population (46.7%) followed by the older child (33.3%). This is also observed in many series in the literature, the deafness of children seems to be prioritized because it would present better chances for a prosthetic benefit; because of the good neural plasticity that they present in the first years of life. This was demonstrated in the work of Svirsky and Holdont who showed that subjects implanted at a young age produce better performance under implant [10] [11]. However, the adult subject was eligible because his hearing loss was post-lingual and post-traumatic.

In the infant population, deafness was mostly (86.7% of cases) suspected by the parents; in front of a delay in language or an absence of reaction to loud noises, at an average age of one year, this denoting the pre-lingual character of the deafness in our series. The diagnosis itself was made clinically at an average age of 3 years, for cochlear implantation at an average age of 4.9 years (1.5 years-8 years). This means a mean diagnostic delay of two years and a mean sound deprivation delay of 4.2 years (0.5 years-7 years). This time of deprivation was one year for the adult subject. The time to sound deprivation could have been reduced if the deafness was detected earlier and the children's implantation ages were earlier. This was the case in the South African experiment in 2015, where a deprivation time of two and a half years was observed; but also in Morocco in 2010 and in Ivory Coast in 2018, where the average implantation ages were 3.3 and 3.8 years respectively [5] [6] [12]. Indeed, Svirsky and Holdont's work in 2004 on 96 children showed that children implanted before the age of 2 years performed better on language skills tests than those implanted after the age of 2 years. Auditory areas that are not stimulated during the first years of life are progressively reinvested in other functions as part of transmodal reorganisation, the so-called "colonisation of auditory areas" [11]. Ignorance of the possibilities

of early diagnosis and management by parents and even by health professionals has contributed to the delay in diagnosis. The financial barrier has also contributed, even when deafness has been detected, to the delay in the management of our patients. This is why the opportunity to donate implants via the ALDAC association has considerably improved the procedure.

5.1.3. Schooling

The school levels were those of the kindergarten for those enrolled in the traditional school, we were not able to assess the academic performance, but it seems obvious that the socialisation of the children and their placement in a learning environment would stimulate their cognitive abilities and improve their psychomotor development while developing their ability to communicate with the environment, even in a non-verbal manner. However, studies recommend not putting children in special schools for the deaf in whom oral language is intended to develop, as this would favour the more rapid colonisation of the auditory areas and their reactivation in the case of late implantation may prove difficult or even incomplete [10] [11].

5.2. Clinical Profile

5.2.1. Risk Factors

In our series, 57.1% of the children (8) had risk factors during pregnancy, the perinatal period and early childhood that could lead to acquired deafness. The factors found were infectious: meningitis, congenital rubella, neuromalaria. But also other factors such as neonatal asphyxia, extreme prematurity and its contingent of associated disorders (jaundice, severe anaemia, low birth weight). These are risk factors commonly accepted in the literature as contributing to acquired deafness. The same factors were found by Hssaine in Morocco and by Ohouo in Ivory Coast [5] [7]. However, we cannot establish with certainty a cause and effect relationship in our population given the low representativeness of our numbers and the fact that some patients had several of these factors. This highlights the need for neonatal hearing screening in these risk groups in order to identify the imputability of these risk factors to the occurrence of acquired hearing loss in our context. If it is accepted, however, that the DRFs found in our study could explain the deafness in the 57.3% of children who presented with them, then our figures are close to those of Wonkam *et al.* in 2015 who found in Cameroon 30% - 50% genetic etiology of deafness and 50% - 70% acquired causes [2] [13] [14]. In 2018, 50% of the patients implanted in Côte d'Ivoire also had these DRFs of deafness. The aetiologies of the other 46.7% of children in our study could be attributed to non-syndromic congenital causes or to unknown causes. In France and in countries where there are few public health problems, nor high proportions of infectious risk as is the case in sub-Saharan Africa, it is now thought that 80% of childhood deafness is genetic in origin [15]. In Cameroon, genetic studies were carried out by Wonkam *et al.* [14] to determine the proportion of genetic causes in deafness, but the result

was that the gene mutations observed elsewhere were not the same in our population.

No history of familial deafness was noted in our series as in the work of Ohouo in IC and Hssaine in 2010 [5] [6]. But larger series such as those from Nigeria and South Africa did [12] [16] [17].

5.2.2. Associated Conditions

Four patients had conditions associated with deafness on physical examination, namely: myopia, cerebral palsy, sequelae of chronic otitis media and head injury syndrome. All the deafnesses were neither malformative nor syndromic. The results of Ohouo in Ivory Coast did not find any associated affection. Hssaine in Morocco in the series studied in 2014 found four syndromic pictures (Waardenberg in 3 patients and Susac in one patient) and associated conditions in three patients such as unilateral blindness, heart disease and left hemisphere paresis. In South Africa, Leroux *et al.* in 2015 in a series of 248 children implanted, found 10% with syndromic deafness (Waardenberg, Usher, Pierre Robin, Leopard) but also associated conditions in 23.5% of children (visual disorders, CMI, autism) [12].

5.3. Paraclinical Profile

The hearing tests performed in our series were: otoacoustic emission (OAE) (46.7%), tonal or behavioural audiometry (64.3%) and EPA (93.3%). These tests were useful for diagnosing and characterising the deafness. In terms of imaging (CT and MRI), 100% of the patients underwent these examinations, which made it possible to eliminate contraindications to surgery and to evaluate associated morphological lesions. In Ohouo's IC study, EPA was performed in 66.6% of patients and audiometry in 8.3% of patients and the most prescribed test was the auditory steady state responses (ASSR) in 83.3% of cases [5]. The ASSR was not performed in any patient in our series.

5.3.1. Audiometric Measurements

The measurement of OAE, which is increasingly recommended in the context of early detection of deafness, especially in the neonatal period, was only performed in half of the children in our series. This still indicates that it is not widely used as a screening test, although its results were unquestionably suggestive of sensorineural hearing loss in all the children who underwent it in our series.

Subjective audiometry (tonal and behavioural) was performed in 64.3% of the patients, all of whom were bilaterally affected, and after calculation of the average hearing loss, 77.7% of the cases had hearing loss thresholds ranging from profound to cophosis. This examination could not be performed in all patients in our series because the specialists qualified to perform it were not always available.

The EPA is the audiometric measurement that was the most frequently performed in our series (93.3%) and therefore the most representative for deter-

mining the type of deafness in our population. All cases were bilateral and symmetrical in 85.7% of cases. Asymmetrical hearing loss was found in 14.3% of cases. The majority of cases had deep hearing loss thresholds (78.6% of cases). According to laterality, the right ears were the most profoundly affected, *i.e.* 92.8% on the right as against 78.6% on the left.

In total, the results of these different measurements enabled us to characterise the hearing losses from an audiometric point of view as being all bilateral and mostly symmetrical. The threshold of the hearing losses was 78.6% deep, with the most marked impairment on the right.

5.3.2. Imaging

The imaging studies (craniocerebral and rock MRI and CT) performed in our series showed abnormalities in four patients (26.7%) but none of these abnormalities were an absolute contraindication to implantation. These abnormalities were: bilateral fracture of the temporal bone, left round window abnormality (round window recess stenosis), non-progressive hydrocephalus, right vascular-nervous impingement and periventricular leukopathy. Contraindication lesions such as inner ear agenesis or absence of cochlear nerve were not found in our series. In the series by Hssaine *et al.* in 2014, a unilateral complex cochlear malformation was identified on imaging in one patient, thus orienting the implant to the contralateral side [6], thus highlighting the absolute necessity of the imaging work-up in the choice of the laterality of the implant, but also to exclude cases with morphological contraindications.

5.3.3. Prosthetic Trial Prior to Implantation

Five patients in our series had received a prosthetic trial before implantation, but only two of them had a prosthetic gain. The prosthetic benefit was estimated to be 30 dB because the wearing of the prosthesis in these patients was accompanied by speech therapy, unlike the other three. The literature recommends a prosthetic trial as a preliminary step to cochlear implantation and should only be done if there is no improvement after six months of speech therapy [18]. In Marakech in 2014, Hssaine *et al.* also reported six cases of a prosthetic trial before cochlear implantation in their series of 54 patients [6].

5.3.4. Pre-Implant Speech Assessment

The pre-implantation speech and language assessment was performed in all patients in our series, but no psychological evaluation was performed. This was also the case in the series of patients implanted in the Ivory Coast and evaluated in 2018 by Ohouo *et al.* [5]. This shows the lack of psychological support in our care despite the desire shown by 100% of parents for oral communication of their deaf children.

The arguments for oral communication were found in 92.9% of the children after speech therapy evaluation. The only child who did not show an aptitude for oral communication had the advantage of being in the age range considered ideal for implantation in literature [18].

5.4. Therapeutic Profile

5.4.1. Indications

Indications were based on a range of arguments relating to the patient's age, the clinical and audiometric characteristics of the deafness, but also the morphological characteristics presented on imaging and the opinion of the speech therapist.

5.4.2. Laterality of the Implant

Unilateral implants were performed in our series with 13 implants placed on the right and two on the left. Recommendations in the literature are increasingly in favour of sequential bilateral implantation [19] [20] for a better auditory and linguistic outcome, but given the cost of the implant and the difficulties in low-income countries, it is more obvious to do unilateral implantations, so in most Central African countries the challenges still come down to the success of the unilateral implant and acquiring optimal performance [5] [21].

5.4.3. Operator

The surgical technique was unique in that the surgeries were performed by the same operator for all patients in our study, a foreign operator assisted by local teams. Indeed, in the early days of cochlear implant programmes in Africa, it is common to see collaborations of this nature in order to facilitate the learning process for local operators. The aim is to limit medical evacuations, promote the sharing of expertise and allow accessibility in terms of cost for patients. Unlike other countries such as Nigeria or Senegal, which in the beginning had to make medical evacuations to the United States of America and France [17] [22] at considerable cost. These partnerships have enabled Cameroon to perform its first surgeries at home and at lower costs.

5.5. The Approach

It was retroauricular in our series as in the one presented by Ohouo in Ivory Coast [5]. The cochleostomy approach in our series was via the round window by accessing it through a posterior tympanotomy. This is the same route used in the Ivorian and Moroccan series.

5.5.1. Anatomical Location of the Electrodes

The implant in our series was placed intracochlearly in the tympanic ramp, passing through the round window at a depth of between 20 and 25 millimetres. This location is the one used in the series done in Marrakech and in Ivory Coast; it would present more interest in that, the proximity with the nerve fibres would allow a greater precision of the sensory targeting in situ with a lesser power of the only electric stimuli. However, there is a risk of injury to residual auditory fibres when the diagnosis of total deafness is not certain.

5.5.2. Operating Features

In our series, we had two operative peculiarities that presented themselves. The first was the stenosis of the round window recess in one patient. This particular

situation was anticipated by imaging and was the result of a post-meningitis complication. However the cochlear tube lumen was normal. This clinical situation was effectively managed by a more prolonged and careful milling of the round window recess in order to give free access to the passage of the electrode holder.

The second surgical feature encountered was the reinforcement of the cortical-fascial recess by gentle milling of the cortical bone of the temporal bone, forming a bed for the internal processor of the implant. This is a feature that was not described in the Moroccan and Ivorian series, probably related to the conformation of the internal processor of the Oticon® implant. In the Ivorian series, the Sonata® brand implant from Med-El® was used in 83.3% of cases and had an extremely thin internal processor, ideal for children.

There were no particularities in terms of anaesthesia and the procedures were all well tolerated in the immediate postoperative period.

5.5.3. Surgical Assessment

The success of the operation could be checked on the first post-surgical day by the Sternvers incidence radiographs, which allowed us to verify the complete winding of the electrode holder in the tympanic ramp in two turns. At the control of the surgical wound we noted a case of superinfection that occurred at ten days post-operatively and although the cause could not be isolated, the evolution was favourable under triple antibiotic therapy. Cases of superinfection of the surgical wound have often been reported in series in northern Nigeria without any impact on the success of the operation. The most feared infectious complications are postoperative meningitis [16], hence the need to remain very rigorous in the respect of aseptic measures.

5.5.4. Prosthetic Assessment

Activation took place within a normal time frame of four to five weeks post-implantation in all patients. It consisted of putting the external and internal parts in contact with each other, progressively imparting the first sound stimuli on the electrodes in groups of four electrodes, up to twenty, and seeking the patient's comfort threshold. The impedance measurements were taken and then the internal processor programs were adjusted. All this was done through a digital interface connected to the internal processor.

- We noted during the activations in one of the patients, an alteration in the functioning of two electrodes in the internal part of the implant. This was probably due to poor postoperative follow-up (wound care was done outside the hospital without medical advice).
- Two external processor failures were reported after activation and these were related to poor handling (devices broken during children's play). These were resolved within a short time and without cost.
- Another internal processor malfunction was reported: post activation in the adult patient it was probably related to scarring fibrosis on a fracture site

which damaged 12 electrodes of his implant, after one year of effective operation and return of hearing.

All these incidents make us realise the damaging nature of the device and draw attention to the precautions to be taken in its maintenance. But they also highlight the problems associated with cochlear implant treatment of fractured bones.

In our series, implant adjustments, which should have been done on a monthly basis, were done on a quarterly basis. This was due to the lack of qualified audiologists in the field to perform more frequent adjustments. These adjustments were punctuated by implantation missions most of the time and the containment phenomenon linked to the pandemic in Covid-19 contributed to further delaying them. However, this disadvantage could be overcome by the progressive adjustment of remote programmes (ECAPs).

6. Limitation of the Study

In the end of this study, we notice some limitations:

The small size of our sample, and the few period of patients' follow-up, was not permitting us to have a precice data. And the future study should be done with a larger sample.

Some file was incomplete, and was not easy to collect data.

We have used only one implants of the brand OTICON®.

7. Conclusion

This study, carried out to evaluate the preliminary outcome of the cochlear implant programme in Cameroon, enabled us to highlight the cases of fifteen severe to profoundly deaf patients who have been treated in the general hospitals of Yaounde and Douala for almost two and a half years and who have benefited from hearing rehabilitation by cochlear implantation in Cameroon. The cochlear implant could prove to be an effective solution in the fight against severe to profound sensorineural deafness in our context, as is the case in other countries, provided that adequate support is provided at all levels and at each stage of the process towards recovery of hearing.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

References

[1] (2018) S M. Surdité et génétique. https://www.cisic.fr.2018 https://www.cisic.fr/implant/recherche-medicale/390-surdite-et%20-genetique-une-conference-du-du-dr-s-marlin

[2] Lebeko, K., Bosch, J., Nzeale, J.J., Dandara, C. and Wonkam, A. (2015) Genetics of Hearing Loss in Africans: Use of Next Generation Sequencing Is the Best Way Forward. *The Pan African Medical Journal*, **20**, Article 383.

http://www.panafrican-med-journal.com/content/article/20/383/full/
https://doi.org/10.11604/pamj.2015.20.383.5230

[3] Guevara, D.N., Lina-Granade, D.G., Seldran, D.F., Truy, P.E. and Gallego, P.S. (2015) L'implant cochléaire en 2015. 19-32.

[4] Chouard, C.-H. (2010) Histoire de l'implant cochléaire. *Annales françaises d'Otorhino-laryngologie et de Pathologie Cervico-faciale*, **127**, 288-296. https://doi.org/10.1016/j.aforl.2010.09.003

[5] Ohouo Marie Danielle, SAR. (2018) Implantation cochléaire en Cote d'Ivoire. Thèse de Médécine générale, Houphouet Boigny, Côte d'ivoire.

[6] Hssaine, K. and Raji, A. (2011) L'implantation cochléaire : Expérience du service d'Oto-rhino-laryngologie du CHU Mohammed VI (2007-2010).

[7] Benlemlih Mohamed, A. (2014) Evaluation des enfants implantés c5ochléaires [Mémoire pour diplôme de spécialité en médecine option: Oto-Rhino-Laryngologie]. Universite Sidi Mohammed Ben Abdellah, Fas.

[8] Oticon Medical (2020) Spécifications techniques du systèmes d'implants cochléaires. https://www.oticonmedical.com/

[9] Cariou, P.G. (2006) Evaluation du programme d'implantation cochleaire pediatrique au chu de nantes. Ph.D. Thesis, Université de Rouen, Rouen.

[10] Leybaert, J. and Colin, C. (2007) Le rôle des informations visuelles dans le développement du langage de l'enfant sourd muni d'un implant cochléaire. *Enfance*, **59**, 245-253. https://doi.org/10.3917/enf.593.0245

[11] Svirsky, M.A., Teoh, S.-W. and Neuburger, H. (2004) Development of Language and speech perception in Congenitally, Profoundly Deaf Children as a Function of Age at Cochlear Implantation. *Audiology and Neurootology*, **9**, 224-233. https://doi.org/10.1159/000078392

[12] Le Roux, T., Swanepoel, D.W., Louw, A., Vinck, B. and Tshifularo, M. (2015) Profound Childhood Hearing Loss in a South Africa Cohort: Risk Profile, Diagnosis and Age of Intervention. *International Journal of Pediatric Otorhinolaryngology*, **79**, 8-14. https://doi.org/10.1016/j.ijporl.2014.09.033

[13] Lebeko, K., Manyisa, N., Chimusa, E.R., Mulder, N., Dandara, C. and Wonkam, A. (2017) A Genomic and Protein-Protein Interaction Analyses of Nonsyndromic Hearing Impairment in Cameroon Using Targeted Genomic Enrichment and Massively Parallel Sequencing. *OMICS: A Journal of Integrative Biology*, **21**, 90-99. https://doi.org/10.1089/omi.2016.0171

[14] Wonkam, A., Bosch, J., Noubiap, J.J.N., Lebeko, K., Makubalo, N. and Dandara, C. (2014) No Evidence for Clinical Utility in Investigating the Connexin Genes GJB2, GJB6 and GJA1 in Non-Syndromic Hearing Loss in black Africans. *The South African Medical Journal*, **105**, 23-26. https://doi.org/10.7196/SAMJ.8814

[15] CISIC (2021) Surdité et génétique, une conférence du Dr S. Marlin. https://www.cisic.fr/implant/recherche-medicale/390-surdite-et%20-genetique-une-conference-du-du-dr-s-marlin

[16] Suleiman, A.O., Suleiman, B.M., Abdulmajid, U.F., Suleiman, M.R., Mustapha, A.Y., Afolabi, O.A., *et al.* (2014) Paediatric Cochlear Implantation in North-Western Nigeria Case Report and Review of Our Challenges. *International Journal of Pediatric Otorhinolaryngology*, **78**, 363-365. https://doi.org/10.1016/j.ijporl.2013.10.061

[17] Adoga, S., Anthis, J., Green, J. and Nwaorgu, O.B. (2014) Our Experience with Cochlear Implant Surgery on Nigerians. *Indian Journal of Otology*, **20**, 134-139.

[18] Szyfter, W., Karlik, M., Sekula, A., Harris, S. and Gawęcki, W. (2019) Current Indi-

cations for Cochlear Implantation in Adults and Children. *Polish Journal of Otolaryngology*, **73**, 1-5. https://doi.org/10.5604/01.3001.0013.1000

[19] Baron, S., Blanchard, M., Parodi, M., Rouillon, I. and Loundon, N. (2019) Sequential Bilateral Cochlear Implants in Children and Adolescents: Outcomes and Prognostic Factors. *European Annals of Otorhinolaryngology, Head and Neck Diseases*, **136**, 69-73. https://doi.org/10.1016/j.anorl.2018.09.004

[20] Le Roux, T., Vinck, B., Butler, I., Cass, N., Louw, L., Nauta, L., *et al.* (2016) Predictors of Pediatric Cochlear Implantation Outcomes in South Africa. *International Journal of Pediatric Otorhinolaryngology*, **84**, 61-70. https://doi.org/10.1016/j.ijporl.2016.02.025

[21] Byaruhanga, R., Jr Roland, J.T., Buname, G., Kakande, E., Awubwa, M., Ndorelire, C., *et al.* (2016) A Case Report: The First Successful Cochlear Implant in Uganda. *African Health Sciences*, **15**, 1342-1348. https://doi.org/10.4314/ahs.v15i4.38

[22] Tropicale, A.S. (2016) Surdité : Un projet de pose d'implant fait naître l'espoir pour les patients sénégalais. http://www.santetropicale.com/actus.asp?id=22694&action=lire