Clinical Experience of Bone Anchored Hearing Aid: A Case Report

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To improve conventional bone conduction hearing aids, Tjellstrom, Branemark, developed an implant system consisting of a maxillofacial implant that derived from dental implants and a bone conduction hearing aid that was attached directly to the implant. This system has been commercially available as a bone anchored hearing aid (BAHA). More than 10,000 patients have benefited from BAHA in Scandinavia, North America, and many other regions. BAHA first became available in 1977 in Sweden but has not been used in Japan as widely as expected. This paper reports a case of a 8-year use of BAHA for hearing loss caused by microtia and external auditory canal atresia, with a review of literature. The patient has been followed up for 9 years after implant placement. Play audiometry with a loudspeaker showed a hearing loss of 25 dB. The patient says that BAHA is superior to conventional transcutaneous bone conduction hearing aids in easiness of attachment, esthetics, and speech recognition and music recognition. The skin and the bone around the implants remain in favorable condition. She has been free from the use of a headband for a conventional hearing aid.

Key words: BAHA, Bone Anchored Hearing Aid, Microtia

INTRODUCTION

Hearing impairments caused by microtia vary with the degree of hypoplasia of the ear. Hypoplasia of the external auditory canal and the middle ear causes hearing loss. Typically, hearing impairment associated with microtia is conductive hearing loss, and hearing aids are helpful for patients with this type of hearing loss. Conventional air conduction hearing aids, however, are not appropriate for patients with external auditory canal atresia. Patients with unilateral microtia are unlikely to use hearing aids because their unilateral hearing loss is not severe enough to interfere with daily activities. Most patients with bilateral microtia have severe hearing loss and begin requiring hearing aids in infancy. In these patients, bone conduction hearing aids are used with a headband.

In the use of a common bone conduction hearing aid, the oscillator is placed on the skin of the mastoid or temporal region with a headband or eyeglasses. This type of hearing aid have five major disadvantages: (1) sound conduction is not satisfactory because the oscillator percutaneously transmits sound vibrations to the skull; (2) a headband that holds the oscillator is not esthetically pleasing; (3) a headband does not have sufficient pressure to hold the oscillator securely during heavy physical activity such as sports; (4) the oscillator may cause pain or discomfort at the application site; and (5) bone conduction hearing aids have become less available, and fewer and fewer manufacturers can repair or customize the devices to fit the configuration of patient's ear.

To improve these disadvantages, Tjellstrom, Branemark, and their co-workers developed an implant system consisting of a maxillofacial implant that derived from dental implants and a bone conduction hearing aid that was attached directly to the implant.[1)2)7)] This system has been commercially available as a bone anchored hearing aid (BAHA) from Entific Medical Systems (Gothenburg, Sweden). More than 10,000 patients have benefited from BAHA in Scandinavia, North America, and many other regions. The indication of BAHA has been extended from microtia-related hearing loss to other types of hearing losses because BAHA is easy to attach and can improve patient's quality of life.

BAHA first became available in 1977 in Sweden but has not been used in Japan as widely as expected. To our knowledge, we are the first Japanese surgeons who performed implant surgery for the use of BAHA and have followed up the initial case. This paper reports a case of a 8-year use of BAHA for hearing loss caused by microtia and external auditory canal atresia, with a review of literature.

CASE REPORT

In 1982, a girl was born at a gestational age of 38 weeks with normal delivery. The birth weight was 2800 g. Two weeks later, she was referred to us because of bilateral microtia and external auditory canal atresia. The initial examination revealed not only these congenital anomalies but also micrognathia and an accessory auricle on the left cheek without facial nerve palsy. We initially suspected Pierre Robin sequence, but the patient had no symptoms or signs of airway obstruction.

The patient began speech therapy with our speech therapist. At 13 months of age, she seemed to have substantial hearing. She could say several words including "papa" and "bow wow". We considered that a conven-

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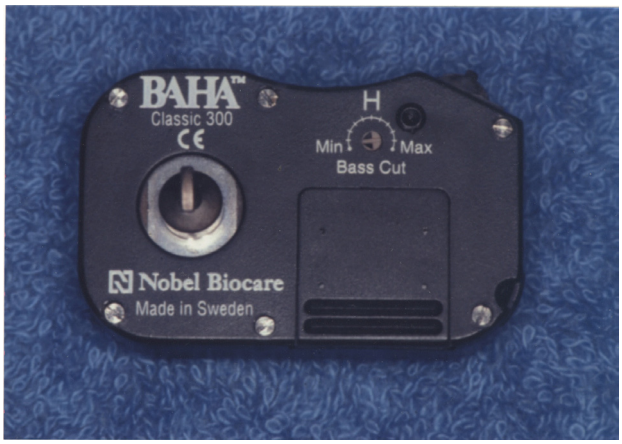

Fig. 1. BAHA (Classic 300, Entific Medical Systems)

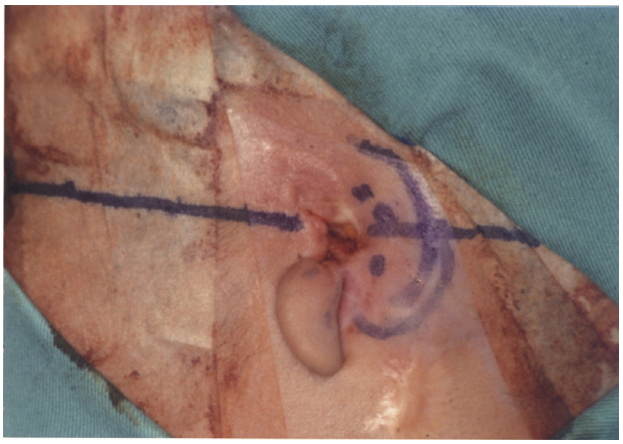

Fig. 2. The implant sites were selected by measuring 15 mm from the superoinferior edge of external auditory canal on three-dimensional images

tional bone conduction hearing aid with a headband would be applied to her, if needed, when she became old enough to use it.

At 19 months of age, patient's development was tested by the speech therapist. The developmental quotient (DQ) was 100 according to the Tsumori-Image Developmental Questionnaire and 92 according to the MCC Baby Test. Hearing was also tested. The patient did not respond to her name called from 30-cm behind or to a bell rung from 1-m behind.

At 20 months of age, the need of a hearing aid was assessed in cooperation with the department of otorhinolaryngology. Since play audiometry showed a mild hearing loss of 20 to 30 dB, we did not consider that the patient needed a hearing aid.

At 2 years of age, patient's DQ was 100 according to the Tsumori-Image Developmental Questionnaire and 91 according to the MCC Baby Test. The DQ for the MCC Baby test was lower than the previous DQ. In this test, children aged 20 months or older are asked to point objects in response to a spoken voice. The patient, however, did not point them because she could not hear the voice. Her understanding of language and verbal expression were below the average for her age. We instructed her family to speak to her in a loud voice to give her as much language stimulation as possible.

At 2 years and 1 month of age, the left accessory auricle was removed surgically in our department.

At 4 years and 9 months of age, auditory brainstem response audiometry showed a moderate hearing loss of 50 to 70 dB. We considered that the patient should undergo tympanoplasty and reconstruction of the left external auditory canal to improve hearing at 5 to 6 years of age.

At 6 years and 4 months of age, the patient underwent the two surgeries of the left ear performed in the department of otorhinolaryngology. Operative findings of the left ear included complete external auditory canal atresia, the absence of the incus and the stapes head, malleus deformity, and pneumatic mastoid. Reconstruction of the external auditory canal used full thickness skin graft harvested from the region behind the auricle. Hearing loss improved from 70 to 55 dB, which was not considered sufficient.

At 6 years and 6 months of age (i.e., two months after surgery), the patient began using a hearing aid with a headband. A bone conduction receiver (p11p model; Oticon A/S, Hellerup, Denmark) was used.

When the patient became 10 years old, we considered surgical reconstruction of bilateral microtia. The surgery, however, was postponed because her chest circumference did not achieve sufficient length to provide the necessary amount of costal cartilage. At 12 years of age, the patient and her family wished to use implant-supported auricular prostheses and BAHA.

At 16 years of age, the patient underwent reconstruction of microtia with a maxillofacial implant system (Nobel Biocare AB, Gothenburg, Sweden) and BAHA (Classic 300, Entific Medical Systems) **(Figure 1)**. We performed implant surgery with a two-stage procedure. The first surgery was performed in February 1998. Three fixtures were placed and then covered with a flap, without abutment connection. Before surgery, computed tomography of the head was performed to measure available bone thickness at planned implant sites. The sites were selected by measuring 15 mm from the superoinferior edge of external auditory canal on three-dimensional images **(Figure 2)**. At the sites, the temporal bone was sufficiently thick to hold fixtures. Since the thickness of outer cortical bone was 3 mm, 3-mm long fixtures were selected. Three fixtures were used with consideration for the attachment of auricular prostheses **(Figure 3)**.

The second surgery was performed in July 1998. Skin-penetrating abutments were connected to the fixtures **(Figure 4)**. The superstructure was a short bar framework, and auricular prostheses clipped onto the bar. An attachment for BAHA, which was designed as a branched extension, was soldered to the framework **(Figure 5a, 5b)**. BAHA and auricular prostheses were delivered in June 1999 **(Figure 6)**.

The patient has been followed up for 9 years after implant placement. She has used BAHA every day with great satisfaction. Play audiometry with a loudspeaker showed a hearing loss of 25 dB. The patient says that BAHA is superior to conventional transcutaneous

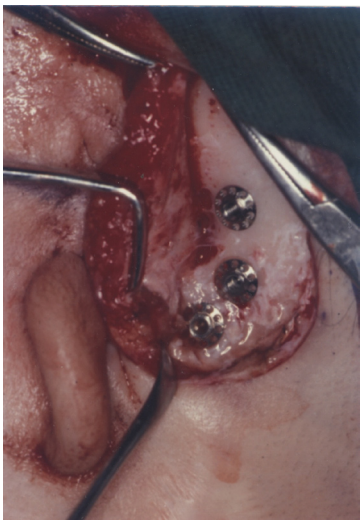

Fig. 3. Since the thickness of outer cortical bone was 3 mm, 3-mm long fixtures were selected. Three fixtures were used with consideration for the attachment of auricular prostheses

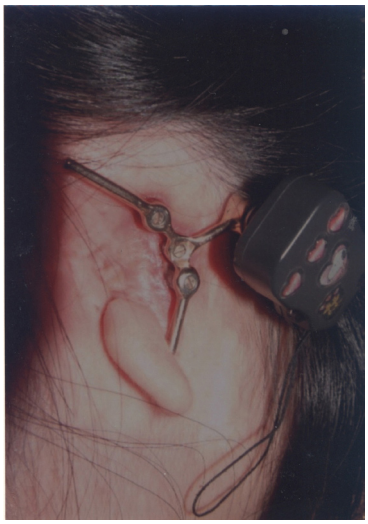

Fig. 4. Skin-penetrating abutments were connected to the fixtures

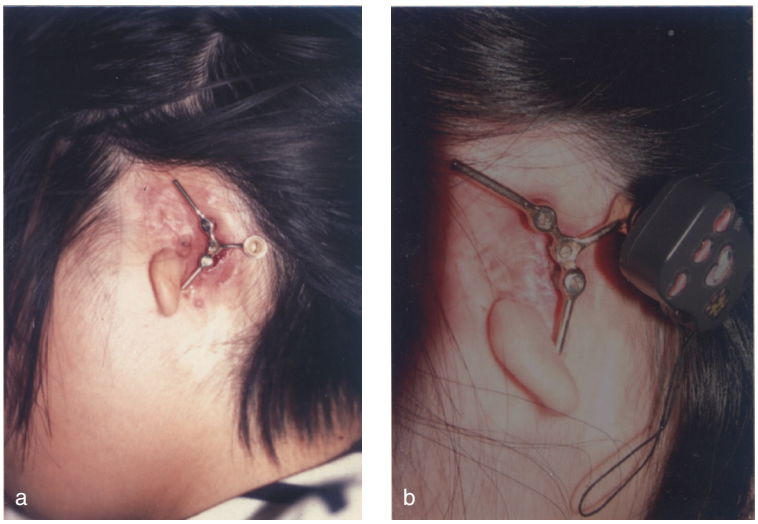

Fig. 5. a): b): The superstructure was a short bar framework, and auricular prostheses clipped onto the bar. An attachment for BAHA, which was designed as a branched extension, was soldered to the framework

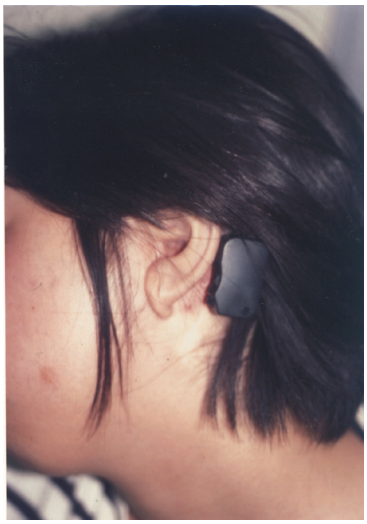

Fig. 6. BAHA and auricular prostheses

bone conduction hearing aids in music recognition. No problems have been reported with speech recognition. She has been free from the use of a headband for a conventional hearing aid. The skin and the bone around the implants remain in favorable condition, although the patient seldom cleans the implant sites. No bone resorption or other adverse reactions have been found. BAHA seems to be usable for at least another 8 to 16 years.

DISCUSSION

In the use of a common bone conduction hearing aid, the oscillator is placed on the skin of the mastoid or temporal region with a headband or eyeglasses. This type of hearing aid has five major disadvantages: (1) sound conduction is not satisfactory because the oscillator percutaneously transmits sound vibrations to the skull; (2) a headband that holds the oscillator is not esthetically pleasing; (3) a headband does not have sufficient pressure to hold the oscillator securely during heavy physical activity such as sports; (4) the oscillator may cause pain or discomfort at the application site; and (5) bone conduction hearing aids have become less available, and less and less manufacturers can repair or customize the devices to fit the configuration of patient's ear. The most notable advantage of conventional transcutaneous bone conduction hearing aids is no need of surgery. This allows patients to begin using the device readily and to avoid paying a surgery fee, a hospitalization fee, and other relevant medical expenses. BAHA is superior to conventional bone conduction hearing aids in easiness of attachment, esthetics, and speech recognition[8)9)].

Hol *et al.* reported the long-term results of BAHA

in 34 patients who previously used air conduction hearing aids[3]. All the patients continued using BAHA and appreciated it in terms of speech recognition, sound comfort, and improvements in ear infections. Improved hearing of the ear with BAHA remained unchanged for more than 10 years (after correction for age) although hearing of the contralateral ear deteriorated with aging. The researchers emphasized favorable outcome of BAHA application in patients who previously used conventional air conduction hearing aids.

Snik *et al.* describe that application of BAHA can re-establish stereophonic hearing in patients with unilateral conductive hearing loss[6].

Some parents of pediatric patients with hearing loss come to know about BAHA and ask their physicians about the application of the device to children. It is often difficult for children to use hearing aids with a headband because of their vigorous physical activity. If BAHA is applicable to children with hearing loss, many such children will benefit from the device.

Seemann *et al.* retrospectively reviewed 25 BAHA implants in 20 hearing loss children aged 18 months[5]. The mean duration of follow-up after implant surgery was 3 years and 7 months. Of 20 original implants, three were lost due to trauma, and two failed to osseointegrate. All the five implants were replaced successfully. BAHA improved hearing in more than 95% of the children. A comparison of preoperative and postoperative hearing loss demonstrated an improvement from 49 to 16 dB on average.

Priwin and Grastrom conducted a retrospective study of surgical problems in 41 children with unilateral BAHA[4]. Available bone thickness was measured in 29 of the 41 children. The mean bone thickness at implant sites of the temporal bone was as thin as 2.5 mm. In 70.5% of the 41 children, implants were placed in contact with the dura or the sigmoid sinus. The implant failure rate was 9.1%. Adverse skin reactions occurred in 7.6% of the children. Despite these problems, the researchers conclude that BAHA is a good option of treatment in children with hearing loss.

In cranioplasty, titanium plates and screws may migrate intracranially because of remodeling of the surrounding bone with bone growth. The same migration could occur when titanium implants are placed in the temporal bone in children. To our knowledge, no reports have been made on the migration.

CONCLUSION

From our experience, BAHA proved a favorable result in the patient with conductive hearing loss caused by microtia and external auditory canal atresia. BAHA was superior to conventional bone conduction hearing aids in easiness of attachment, esthetics, and speech recognition.

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