Abstract

Objectives

Discuss use of a linear incision for placement of a magnetically coupled bone anchored hearing implant.

Methods

Case series

Results

Two patients underwent placement of magnetically coupled bone anchored hearing implants (BAHI) through linear incisions. The first, a 40-year-old female with congenital single-sided deafness, previously had successful implantation of a percutaneous bone anchored hearing implant through a linear incision; unfortunately, she developed pain and intermittent drainage at her abutment site with time, resulting in a request for removal of her device. As an alternative to complete removal, we offered to replace the percutaneous implant with a magnetically coupled BAHI, employing the same linear incision previously. The second patient, a 53-year-old obese female with limited neck mobility and mixed hearing loss, underwent primary placement of a magnetically coupled BAHI through a linear incision. Limitations in neck mobility and patient body habitus precluded use of a traditional C-shaped incision. Both patients underwent surgery successfully, healed without incident, had their devices activated 6 weeks after their procedures, and are able to wear their implants more than 8 hours per day without discomfort.

Conclusion

Surgical techniques for bone anchored implants continue to evolve. Though manufacturers of magnetically coupled devices recommend using C-shaped incisions with large skin flaps, our first reported cases suggests that a small linear incision immediately overlying the implant magnet may be an acceptable alternative. Potential benefits include a smaller incision, less hair removal, smaller flap, decreased surgical time, and less post-operative pain.

First Report: Linear Incision for Placement of a Magnetically Coupled Bone Anchored Hearing Implant

Introduction

Bone anchored hearing implants (BAHIs), developed from titanium dental technology, have evolved significantly since their introduction in 1977.[1,2] Likewise, surgical techniques for placement of these devices have also progressed. For example, the placement of early generation devices was staged to allow for osteointegration prior to abutment placement.[3] Until recently, percutaneous BAHIs were the only surgical option for patients with single-sided deafness or mixed/conductive hearing losses that did not want traditional hearing aids or CROS (contralateral routing of signal) devices.[4,5]

When first introduced to clinical practice in the United States, placement of percutaneous BAHIs required use of a dermatome to raise an inferiorly based split thickness skin flap. Wide undermining was necessary for removal of underlying soft tissues, exposing bone, and for placement of the implant.[6] Infection and other complications related to poor wound healing were not uncommon.[7] Over time, C-shaped incisions with less soft tissue resection replaced earlier techniques. Finally, as a greater choice in abutment lengths became available, a transition to linear incisions, and most recently, the punch technique, has occurred.[6,8-13]

Magnetically coupled devices have made bone conduction hearing implants more attractive to patients. Surgery for these devices requires implantation of a bone anchored magnet which couples to an externally worn bone conduction hearing aid via another magnet - rather than a percutaneous abutment.[14] Without percutaneous abutments, these devices are cosmetically appealing and have minimized post-operative care.

Current surgical guidelines recommend a C-shaped incision placed at least 1.5 cm away from the anticipated edge of the underlying magnet, theoretically preventing direct pressure to the suture line upon application of the external sound processor.[15] This requires making a relatively

long incision, raising large skin flaps, undermining widely, and potentially resecting a large volume of soft tissue during implant placement (Fig 1). We present the first two published cases of linear incision employed for placement of magnetically coupled BAHIs (Fig 2). Although both patients had significant comorbidities which could interfere with wound healing, both healed without complication, suggesting that a linear incision may be a viable alternative for initial placement of magnetically coupled BAHIs (Fig 3).

Methods

Two patients undergoing Baha Attract™(Cochlear Ltd; Sydney, Australia) implant surgery were offered surgery through a small linear incision. The medical records of these patients were then reviewed to determine postoperative wound healing outcomes. The first patient was a 40-year-old female with congenital single-sided deafness. She underwent uneventful placement of a percutaneous implant through a linear incision with excellent audiometric benefit. Months later, she developed pain and intermittent small-volume drainage at her abutment site. She was first managed conservatively with oral antibiotics and topical therapies; however, persistent symptoms, especially pain, limited use of her device. Eventually, she requested removal of her implant. As an alternative, we discussed replacing the percutaneous device with a magnetically coupled device by using her already osteointegrated implant to attach a new implant magnet as a single stage operation. The sound processor and its magnet would then be worn externally on the head to deliver vibratory energy to the underlying implant.[15] The patient elected to proceed. The same linear incision used previously for the percutaneous device was utilized, removing an ellipse of skin around the abutment site to freshen the edges. The skin flap was approximately 5 mm thick; therefore, no soft tissue reduction was necessary. The magnetically coupled device magnet was placed on the preexisting abutment as a single stage procedure. The incision was then closed in two layers and a ten-day course of oral antibiotics was prescribed.

The second patient was a 53-year-old woman with long history of Eustachian tube dysfunction, recurrent ear drainage and mixed hearing loss on the right. This patient had a BMI of 48.3 kg/m^2, limited neck mobility, and was chronically anti-coagulated due to prior stroke. She had difficulty wearing conventional hearing aids due to ear drainage. After informed discussion regarding BAHI surgery, the patient underwent a BAHI soft band trial and elected to proceed with implantation of a magnetically coupled device. She was offered implantation through a linear incision as her limited neck mobility and body habitus would make positioning for a C-shaped incision impossible without the use of Mayfield® skull pins (Integra; Plainsboro, NJ) to adequately reach the posterior scalp. After counseling regarding the potential risks of the linear incision, including wound breakdown, increased pain, decreased ability to tolerate multi-hour wear of her device, need for revision surgery, and informing the patient that this was not currently recommended incision type by the manufacturer, the patient elected to pursue implantation via a linear incision. Her device was placed through small linear incision 65 mm posterior to the external auditory meatus with 6 mm skin flaps. The skin was closed in two layers over the device, and a ten-day course of oral antibiotics was prescribed.

Results

Surgery and post-operative healing were uneventful in both patients (Fig 4). Pain and drainage completely resolved for the first patient with placement of the magnetically coupled BAHI. Both patients had their devices activated 6-weeks after surgery and reported immediate audiometric benefit. With 1 year and 6 month follow-up respectively, they remain pleased with their outcomes. Both patients demonstrate well-healed incisions with no evidence of inflammation or skin breakdown. This compared to our previously published series of 4 patients implanted with the same device via traditional C-shaped incisions, in which one patient developed minor skin reaction.[16] The linear incision patients are able to use their implants more

than 8 hours per day without discomfort and report no pain at the incision site. Both patients expressed complete satisfaction with their surgical and audiometric outcomes.

Discussion

Wound healing is a complex but stepwise process involving inflammation, soft tissue proliferation, and wound maturation. Many patient factors have the potential to impact outcome, and the operating surgeon must take such factors into consideration. Risk factors include smoking, obesity, cardiovascular disease (hypoxia, hypoperfusion), malnutrition, diabetes, or the immunocompromised on medications like corticosteroids.[17] Additionally, patients with prior infections at surgical sites, such as our first patient, are also at increased risk for wound complications. In high-risk populations, extra care must be taken in surgical planning. In the same token, advancements in surgery frequently mirror changing clinical needs, patient demand, and/or technological advancements. Ultimately, the goal of such innovation is to decrease overall patient morbidity; for example, decreasing incision size, manipulation of soft tissue and anesthesia time as well as minimizing infection risk, decreasing patient morbidity, and improving patient satisfaction.

The evolution of incisions utilized for percutaneous BAHIs has decreased surgical time and infection risk, thereby improving patient satisfaction.[12,18] For magnetically coupled BAHI surgery; there are theoretical benefits and disadvantages for both the traditional C-shaped incision and the shorter linear incision. The C-shaped incision avoids placement of an incision line directly over the implant, potentially decreasing the risk of skin necrosis due to compression between the two magnets. However, this longer flap requires significant soft tissue undermining/resection, thereby putting the flap at risk for vascular compromise and poor healing at its most distal aspect. The shorter linear incision sits directly over the magnet, placing the suture line at risk for tissue necrosis, but potentially avoiding the risk of vascular compromise. Another important consideration is flap thickness. In patients with thin skin, the traditional C-

shaped incision may be more appropriate as the suture line would have very little underlying soft tissues. Placing such a suture line directly over the underlying implant may increase risk for extrusion, infection and skin necrosis.[19] Even with resection of skin at her prior incision site, our first patient had robust 5 mm thickness skin flaps, which likely contributed to her excellent post-operative result. Current guidelines recommend waiting 4 weeks from device placement and activation; we delayed activation in our patients until 6 weeks post-implant in order to allow for a longer wound-healing period.

To our knowledge, there are no published reports of linear incisions successfully used for placement of magnetically coupled BAHIs. Our initial experience, one primary surgery and one revision procedure in two patients at high risk for poor wound healing, suggests that this incision can be free from feared complications like wound breakdown, pain with device wear, and infection. Moreover, a smaller incision requires less hair to be shaved, something that may be of psychological importance to patients. This paper does not purport that one incision is superior to the other; however, results from our two patient experiences suggest that a linear incision may be a viable alternative to currently recommended techniques, especially in patients in whom the C-shape incision is not possible. Despite the first patient's previous history of Baha Connect™ surgery, compromised soft tissue due to history of intermittent infections/drainage, and need for resection of compromised skin from a contaminated area (an even more high risk individual than our second patient who underwent primary surgery), this patient healed without incident.

Conclusion

Surgical techniques for bone anchored hearing implants have evolved dramatically over time. Though manufacturers currently recommend using C-shaped incisions with large skin flaps for implant placement, our first reported cases of Baha Attract™ surgery performed though a linear incision suggests that such incisions are safe, decrease incision size, require less hair

removal, prevent wide undermining/resection of underlying tissue, potentially decrease time under anesthesia, and speed postoperative recovery by minimizing pain.

References

1. Tjellstrom A, Lindstrom J, Hallen O, Albrektsson T, Branemark PI. Osseointegrated titanium implants in the temporal bone. A clinical study on bone-anchored hearing aids. Am J Otol 1981; 2:304-310.
2. Esposito M, Grusovin MG, Maghaireh H, Worthington HV. Interventions for replacing missing teeth: different times for loading dental implants. Cochrane Database Syst Rev 2013; 3:CD003878.
3. Nelissen RC, den Besten CA, Faber HT, Dun CA, Mylanus EA, Hol MK. Loading of osseointegrated implants for bone conduction hearing at 3 weeks: 3-year stability, survival, and tolerability. Eur Arch Otorhinolaryngol 2015.
4. Powell HR, Rolfe AM, Birman CS. A Comparative Study of Audiologic Outcomes for Two Transcutaneous Bone-Anchored Hearing Devices. Otol Neurotol 2015; 36:1525-1531.
5. Taghavi H, Hakansson B, Reinfeldt Set al. Technical design of a new bone conduction implant (BCI) system. Int J Audiol 2015; 54:736-744.
6. Hogsbro M, Agger A, Johansen LV. Bone-anchored Hearing Implant Surgery: Randomized Trial of Dermatome Versus Linear Incision Without Soft Tissue Reduction--Clinical Measures. Otol Neurotol 2015; 36:805-811.
7. Mohamad S, Khan I, Hey SY, Hussain SS. A systematic review on skin complications of bone-anchored hearing aids in relation to surgical techniques. Eur Arch Otorhinolaryngol 2014.
8. Altuna X, Navarro JJ, Palicio I, Alvarez L. Bone-anchored hearing device surgery: Linear incision without soft tissue reduction. A prospective study. Acta Otorrinolaringol Esp 2015; 66:258-263.
9. Martinez P, Lopez F, Gomez JR. Cutaneous complications in osseointegrated implants: comparison between classic and tissue preservation techniques. Acta Otorrinolaringol Esp 2015; 66:148-153.
10. Singam S, Williams R, Saxby C, Houlihan FP. Percutaneous bone-anchored hearing implant surgery without soft-tissue reduction: up to 42 months of follow-up. Otol Neurotol 2014; 35:1596-1600.
11. Hultcrantz M, Lanis A. A five-year follow-up on the osseointegration of bone-anchored hearing device implantation without tissue reduction. Otol Neurotol 2014; 35:1480-1485.
12. Dumon T, Medina M, Sperling NM. Punch and Drill: Implantation of Bone Anchored Hearing Device Through a Minimal Skin Punch Incision Versus Implantation With Dermatome and Soft Tissue Reduction. Ann Otol Rhinol Laryngol 2015.
13. Edmiston RC, Aggarwal R, Green KM. Bone conduction implants - a rapidly developing field. J Laryngol Otol 2015:1-5.
14. Briggs R, Van Hasselt A, Luntz Met al. Clinical performance of a new magnetic bone conduction hearing implant system: results from a prospective, multicenter, clinical investigation. Otol Neurotol 2015; 36:834-841.
15. Cochlear Americas. Cochlear Baha 4 Attract System Surgical Procedure Surgery Guide. . Data retrieved 1/10/2014 from wwwcochlearcom/US 2014.
16. Faucett EA, Reghunathan S, Jacob A. Medicinal honey as treatment for skin reactions associated with bone-anchored hearing implant surgery. Laryngoscope 2015; 125:1720-1723.
17. Anstead GM. Steroids, retinoids, and wound healing. Adv Wound Care 1998; 11:277-285.
18. Gordon SA, Coelho DH. Minimally Invasive Surgery for Osseointegrated Auditory Implants: A Comparison of Linear versus Punch Techniques. Otolaryngol Head Neck Surg 2015; 152:1089-1093.
19. Raine CH, Lee CA, Strachan DR, Totten CT, Khan S. Skin flap thickness in cochlear implant patients - a prospective study. Cochlear Implants Int 2007; 8:148-157.

Figure Legends

Fig 1: Intraoperative skin markings for the traditional C-shaped incision (solid line) used in BAHI surgery.

Fig 2: A: Intraoperative skin markings demonstrating a smaller and more anteriorly located linear incision for magnetically coupled BAHI implantation. B. Surgical planning guide demonstrating adequacy of planned incision length. C. Magnet placed through linear incision with 6 mm skin flaps.

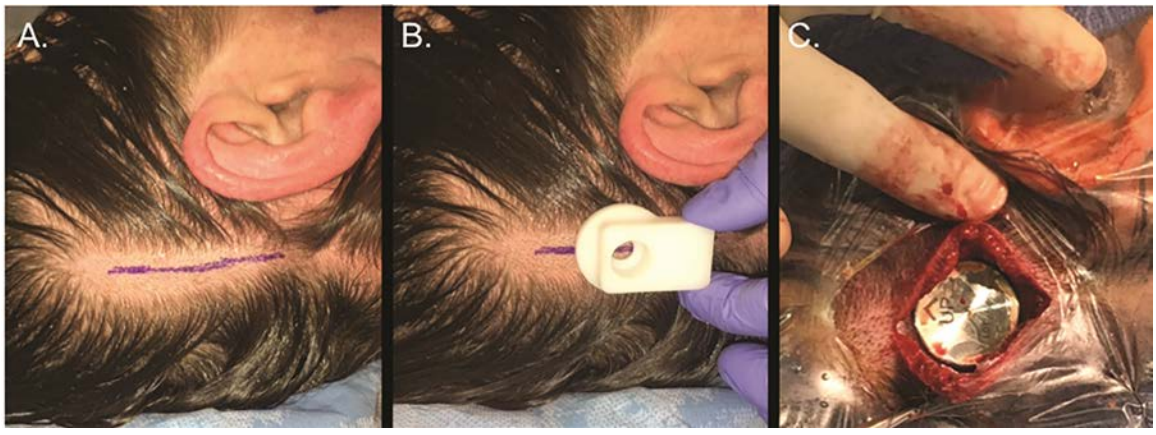


Fig 3: A. Demonstrates recommended C-shaped incision (solid line) for placement of magnetically coupled device magnet (magnet location dotted line). B. Demonstrates a smaller and more anteriorly located linear incision with minimal hair shave.

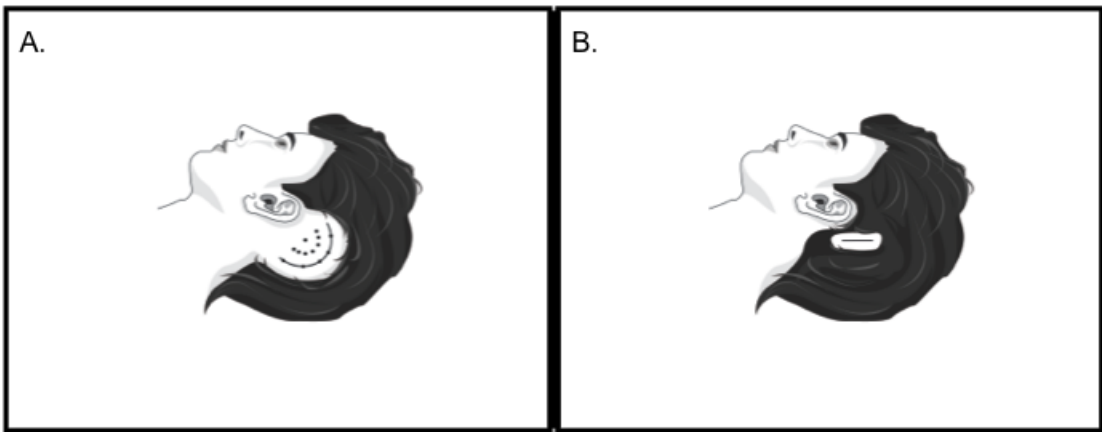
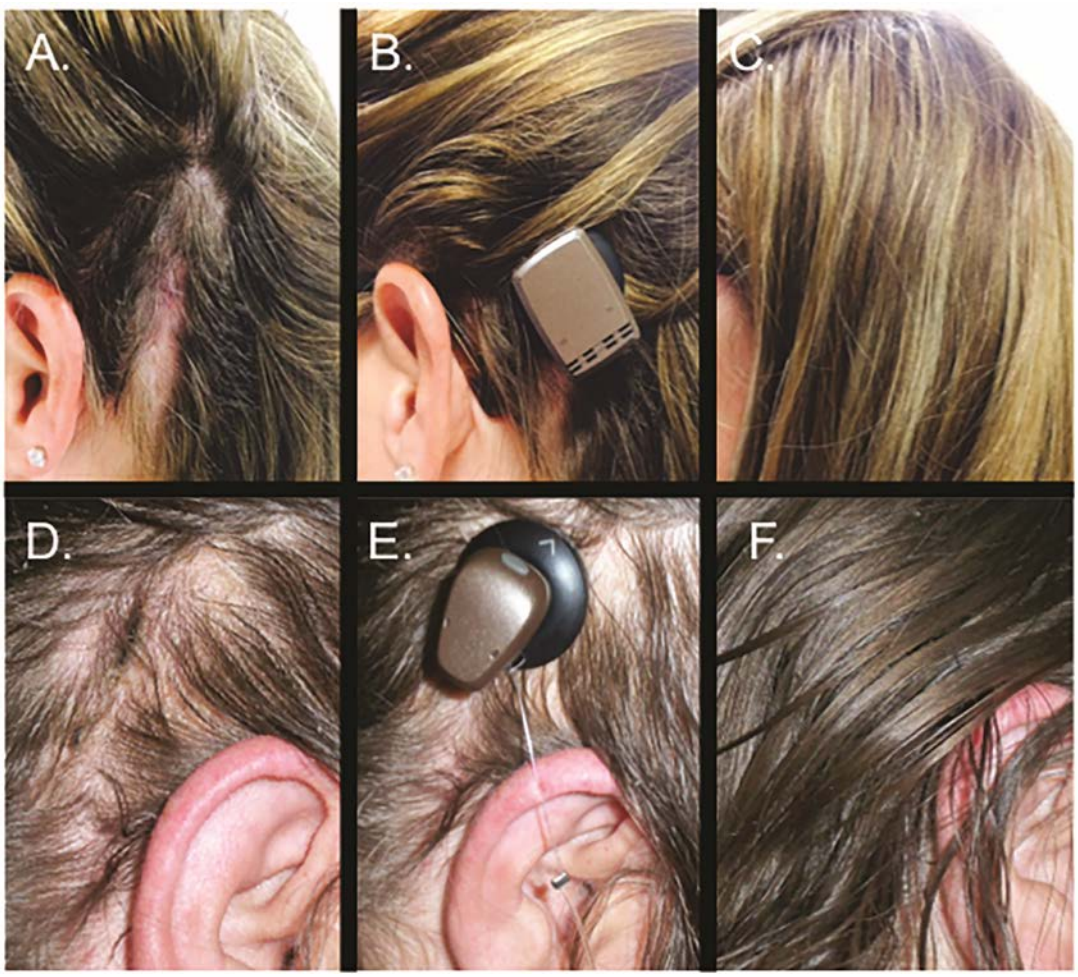


Fig 4: A. Healed linear incision in first patient 3-months after placement of magnetically coupled BAHI. Note some alopecia, likely a result of two surgical procedures in same location. B. Magnetically coupled sound processor in place. C. Hair completely covering the magnetically coupled BAHI device and implant site. D. Healed linear incision of second patient 3-months after placement of device. E. Magnetically coupled sound processor in place. F. Hair completely covering the device.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