Preservation of Nonviable Cranial Bone after Class IV Electrical Burns

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Background: It has been suggested that preservation of nonviable cranial bone is possible in some selected cases in the absence of infection.

Methods: A series of ten male patients, mean age 29±7 with severe electrical scalp burns and nonviable cranial bone were managed conservatively. The patients were treated initially by soft-tissue debridement until the wound presented viable, clean margins. At 22±6 days after the burn, multiple burr holes were made in the nonviable bone, and the defect immediately covered with a well-vascularized scalp flap. Each patient's progress was documented during the hospital stay and during the follow-up for at least one year.

Results: The multiple burr holes filled with fibrous tissue and the contour of the skull was maintained in all 10 patients making the need of a secondary cranioplasty unnecessary. No postoperative infection, osteomyelitis, or cranial bone sequestration occurred.

Conclusions: Even with moderately delayed management of contaminated electrical burns, partial excision of the necrotic bone with burr holes and flap coverage appears to be adequate. [*P R Health Sci J 2010;1:83-85*]

Key words: Electrical burns, Salvage of cranium, Burr holes

Electrical scalp burns represent 3% of all electrical injuries and 1% of all burns (1). These burns, although uncommon, are currently observed more often. Since the value of copper has increased over 700% in recent years, theft of copper from electrical wiring has become rampant throughout the United States and Puerto Rico. Often, the copper wire thief receives an electrical injury which enters the hand that holds the high tension wire and exits at the head when the person falls back, or at the feet if shoes are not insulated. The scalp injury resulting from the electrical current is associated with necrosis of the outer table of the calvarium (class III) or the outer and inner tables of the cranial bone (class IV) as well as destruction of the overlying soft tissue (Table 1). Different therapeutic options have been described on how to manage the nonviable bone and complete the final coverage of the defect (1-8). In this report we describe our experience with partial preservation of nonviable cranial bone and the long-term patient outcomes.

Methods

During the past five years the Plastic Surgery Section of the University of Puerto Rico, has treated 10 patients who suffered full thickness electrical burns of the scalp. These injuries resulted not only in soft tissue loss but also in full thickness non-viable cranial bone at the base of the defect (Figure 1). All patients were males whose mean age was 29±7 years. Initially the patients were admitted to the trauma unit and hemodynamically stabilized. After the patients were stable, the burn wounds were debrided until viable, clean, soft tissue margins were obtained. Reconstructive surgery was performed at an average of 22±6 days after the burn occurred. With the assistance of a neurosurgeon, multiple burr holes, following a grid pattern, were made in the non-viable cranial bone. This grid was immediately covered with a well-vascularized scalp flap, and the donor area covered with a skin graft. The patient's progress was documented during the hospital stay and long-term follow-up at the plastic surgery clinic was provided for at least one year. The sequence of this technique is illustrated in figure 2.

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Table 1. Harrison's classification of the severity of head burns

Harrison's classification of head burns	
Class I	Burn injury with partial thickness soft tissue loss.
Class II	Burn injury with complete soft tissue loss.
Class III	Burn injury with complete soft tissue loss and necrosis of the outer table of the cranial bone.
Class IV	Burn injury with complete soft tissue loss and necrosis of both the outer and inner table of the cranial bone.

Results

All patients were successfully reconstructed by partial preservation of the nonviable bone with multiple burr holes and immediate coverage with a well-vascularized scalp flap. The surgical reconstruction was performed about 22±6 days after the injury. The duration of hospital stay was 29 days on the average. No flap failures were observed. No postoperative infections, osteomyelitis or cranial bone sequestration occurred in this group of patients. Two patients developed minor wound separations due to tension at the suture line, which healed by secondary intention.

Figure 1. Class IV electrical burns of the scalp.

The procedure preserved an adequate skull contour without the need of a secondary cranioplasty as illustrated in figure 3. The multiple burr holes filled with fibrous tissue preserving the contour of the skull and possibly serving as a scaffold for bone regeneration.

All patients were satisfied with the cosmetic result and the only complaints received were associated with the lack of hair at the skin-grafted flap donor sites.

Discussion

Electrical injuries represent a special type of thermal injury, with a pathophysiology depending on the voltage, current flow and resistance. High voltage injury defined as exposure to a voltage of 1000 volts or greater characteristically occurs in an outdoor environment near power sources and lines. The pathway of current can be somewhat unpredictable, but in general, current passes from a point of entry through the body to a grounded site or exit site. The passage of a given current generates more heat in a more resistant conductor (tissue). Therefore, tissues that are less conductive tend to heat up more as current passes through them. The order of tissues, from the most conductive to the least conductive is as follows: nerves, blood vessels, muscles, skin, fat and bone. The difference in conductance is why high voltage thermal damage has a significant deep component and a rather smaller skin injury. Bone also dissipates heat more slowly than other tissues, heating the surrounding tissues even after current ceases to flow. The severity of the bone and deep tissue damage always exceeds the skin damage in electrical injuries.

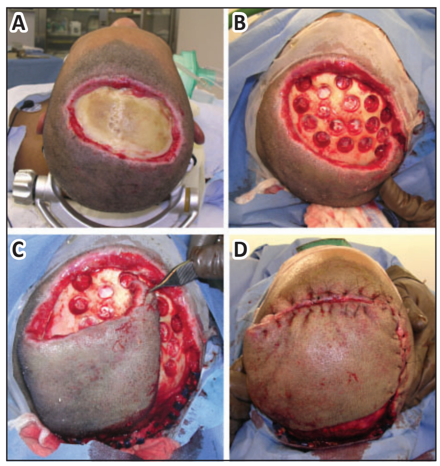

Figure 2. Photographic sequence of the technique: (A) initial defect, (B) burr holes in the nonviable cranial bone, (C, D) final coverage of the defect by rotating a large scalp flap.

High voltage electrical injuries of the scalp have been managed by multiple approaches including partial or complete debridement of necrotic bone, sequential allograft coverage followed by delayed autografting, or immediate autografting (1-6). The flaps used for immediate coverage may be local flaps elevated as random, axial pattern flaps, or free microvascular transferred flaps. It has been reported that no surgical debridement of bone is required in the early stages if the defect is covered with well-vascularized tissue (3). However, others have reported bone sequestration and the need for secondary excision of the infected bone in cases managed by preservation of the complete necrotic bone segment (9-10). Since the goal is preservation of the contour of the skull, this can be obtained by conservative bone debridement leaving a skull grid in situ that may serve as a scaffold for bone regeneration. In our series we did not have any bone sequestration, infection or major complications.

Figure 3. Pre and postoperative views: (A) pre-operative appearance, (B, C, D) postoperative appearance one year after surgery with preservation of the normal cranial contour.

Conclusions

In summary, debridement of non-viable cranial bone due to electrical burns of the scalp can be limited to multiple burr holes in a grid pattern and does not necessarily require removal of the entire section of bone. As reported by others (1-3), if the underlying bone is not infected it can be left in situ covered with well-vascularized tissue. Even in moderately delayed management of contaminated electrical burns, partial excision of the necrotic bone with burr holes appears to be sufficient. Leaving the skull grid in situ serves as a scaffold for bone regeneration. The conservative cranial bone debridement allows the patient to maintain normal cranial contour without the need for a secondary cranioplasty.

Resumen

Introducción: Se ha sugerido que es posible preservar el hueso craneal no viable en algunos casos, cuando no hay infección presente. Método: Una serie de diez hombres, con una edad media de 29±7 años, quienes presentaron con quemaduras eléctricas severas y hueso craneal no viable se trataron de forma conservadora. Inicialmente los pacientes se manejaron con resección del tejido blando necrótico de la quemadura hasta tener márgenes limpios. A los 22±6 días después de la quemadura, se realizaron múltiples trepanaciones en el hueso craneal no viable, y el defecto se cubrió inmediatamente con colgajos regionales de la cabeza con buena irrigación vascular. La evolución del paciente se documentó durante la estadía en el hospital y durante las vistas de seguimiento durante un mínimo de un año. Resultados: Las múltiples trepanaciones en el hueso craneal afectado por la quemadura eléctrica se llenaron de tejido fibroso manteniendo el contorno del cráneo en los diez pacientes, obviando de esta manera la necesidad de una craneoplastía secundaria. No se reportaron infecciones postoperatorias, osteomielitis, o secuestros de hueso craneal en estos pacientes. Conclusión: Aun en el manejo moderadamente tardío de quemaduras eléctricas contaminadas, la resección parcial del hueso craneal necrótico con múltiples trepanaciones seguido de cubierta inmediata con un colgajo regional aparenta ser adecuado.

References

1. Dalay C, Kesiktas E, Yavuz M, Ozerdem G, Acarturk S. Coverage of scalp defects following contact electrical burns to the head: A clinical series. Burns 2006;32:201-207.
2. Roelhl K, Geoghegan J, Herndon DN, Patterson J, McCauley RL. Management of class IV skull burns using bipedicled superficial temporal artery scalp flap. J Craniofac Surg 2008;19:970-975.
3. Hartford CE. Preservation of devitalized calvarium following high-voltage electrical injury: case reports. J Trauma 1989;29:391-394.
4. Bizhko IP, Slesarenko SV. Operative treatment of deep burns of the scalp and skull. Burns 1992;18:220-223.
5. Oishi SN, Luce EA. The difficult scalp and skull wound. Clin Plast Surg 1995;22:51-59.
6. Spies M, McCauley R L, Mudge B P, Herndon DN. Management of Acute Calvarial Burns in Children. J Trauma 2003;54:765-769.
7. Rosenberg MF, Tuchman I, Yardeni BHP, Sternberg N, Golan J. Electrical burn injury of the scalp-bone regrowth following application of latissimus dorsi free flap to the area. Burns 1991;17:338-339.
8. Worthen, EF. Regeneration of the skull following a deep electrical burn. Plast Reconstr Surg 1971;48:1-4.
9. Gumus N, Coban YK, Reyhan M. Cranial bone sequestration 3 years after electrical burn. Burns 2006;32:780-782.
10. Shen Z, Wang N, Ma C. Treatment of extensive deep burn of scalp with full-thickness necrosis of calvarial bone. Zhonghua Zheng Xing Shao Shang Wai Ke Za Zhi 1995;11:10-12.