Ballert ORTHOPEDIC
ORTHOTICS AND PROSTHETICS

THE HALO SYSTEM
PART I
History and Development of the Halo
By Gene Bernardoni, CO

INTRODUCTION

This month we will begin a three part article on the halo orthosis. The halo is used to minimize the movement of the cervical spine either in the treatment of traumatic injuries to the cervical spine or for post-operative support. The halo derives its name from the ring that surrounds the patient's head. The ring is attached by metal or carbon fiber uprights to a jacket vest or TLSO around the patient's chest. All of the halo's components work to immobilize the patient's head and cervical spine. In this and the following articles I will go into greater detail on the history and development of the halo with a detailed description of the components of the halo orthosis, the process of applying the halo; clinical analysis of the halo; and problems related to the halo's use. Finally I will discuss the features of the major halo systems now in use by orthotists.

HISTORY

While some very early texts in orthopedics describe and illustrate devices that performed functions similar to the halo, the modern form of the halo is generally credited to the orthopedic surgeon Frank Bloom, who developed a device for which he was given a US Patent called the "skull clamp". Bloom used the device during WWII on pilots who sustained inwardly displaced facial fractures with overlying skin burns. As part of the halo procedures pins were placed into the facial bones to apply traction to the frac-

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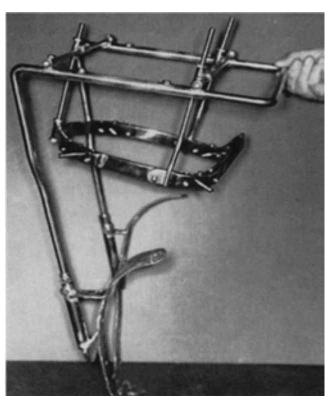

Fig. 1. Perry and Nickel's original halo.

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tures. Outward traction was applied from the connected ring.

Dr. Bloom's device led to development of the halo skeletal-fixator by Dr.'s Vernon Nickel and Jacqueline Perry. The first halo, reported in 1959 in the *Journal of Bone and Joint Surgery* by Perry and Nickel, consisted of a complete ring with an overhead frame attached to a rigid full-body cast by three descending support rods. (See *Fig1.)* The Perry & Nickel halo with its complete ring, attached to a rigid plaster body cast, closely resembles the modern halo both in design and function.

At first, Perry & Nickel used their halo for the arthrodesis of the cervical spine in poliomyelitis patients and then with polio patients with paralytic cervical muscles who were unable to hold their heads upright. The upright head position was necessary to maintain a clear airway for breathing. The halo was also used for the post surgical treatment of scoliosis. Later the basic halo design was adapted to stabilize the cervical spine following trauma, tumor operations, and in the correction of congenital malformations.

The first commercially available halo assembly attached to a plaster body cast was manufactured by Ortho America. The first commercially available halo with its own vest was manufactured by Ace.

While the Perry & Nickel halo's function is similar to today's halo, the use of modern materials and design features, necessary to facilitate modern medical practices and procedures, would make the earlier halo look ancient. Material and design changes have occurred over the years in each element of the halo's design. Reducing the weight of the halo has always been a major goal behind these design changes. Each of the major elements of the halo will be discussed below.

DEVELOPMENT OF RING

Originally the halo's rings were made exclusively of steel with multiple pin insertion holes. The rings were available in different sizes. Each ring was designed with an upward curve posteriorly. The upward curve provided greater surgical exposure. The ring, in turn, was connected to a plaster body cast by three to four metal uprights. Problems developed as a result of these older designs and materials. The steel ring was opaque to x-rays, was not MRI compatible, and the metals used were heavy.

Modern materials and design have overcome many of these problems. Today the ring is made from lightweight composites which are invisible on CT or MRI scans. Open-backed "Crown-type" rings have been developed that increase the safety of application since they do not require that the patient's head be extended beyond the edge of the examination table during ring application.

Fig. 2. Modern halo vest.

DEVELOPMENT OF VEST AND CONNECTING ROD SYSTEMS

Lightweight, adjustable plastic vests have replaced the heavy plaster body jackets that were used to support the halo. (See Fig 2.) These plastic vests may incorporate cross straps and/or rigid plastic straps to decrease shear forces between the anterior and posterior shells. Some modern halo manufacturers utilize a design in which the posterior shell rests on the paraspinal

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Fig 3. Airflow Vest

muscle mass with openings for the spinous process. In this way the spinous processes are not exposed to pressure from the vest. (See Fig. 3.) Modern halos are designed to permit the anterior shell to be lifted to allow for CPR while leaving the remainder of the crown/vest in place. This would have been impossible with the plaster body casts use in the old halo designs.

The connecting rod systems, used to attach the body jacket with the ring, have also developed and improved over the years. Today, low profile designs for the nonferrous metal or carbon fiber uprights make it easier for the patient to wear a halo. Metal uprights are constructed of anodized metal composites to prevent oxidation, and knurled bars prevent slipping. Both of these innovations are important to guarantee the structural integrity of the halo superstructure.

Modern halo upright design allows adjustment of the cervical spine in every plane. Some halo systems have only one-size fasteners for both superstructure and vest, limiting the tools required for application .

DEVELOPMENT OF PIN

The halo pins are critical to the integrity and usefulness of any halo system. The pins provide the direct contact between the skull and the halo. Pin system designs and materials have varied through the years and continue to vary between halo manufacturers. The halo that I most frequently apply uses titanium pins with a broad shoulder design. Although stainless steel pins exist, they are not commonly used as they are not MRI compatible. Current clinical research has indicated that instead of a broad shouldered, pointed pin a pin with a bullet shaped point of lesser diameter may improve contact with the skull and may provide more rigidity at pin-bone interface. (See Fig 4.) A threaded point pin is also another option, although it causes skin twisting.

Fig. 4. Top: Bremeer Pin, Bottom: PMT Pin

An important aspect of the halo application process is the placement and pressure of the pins against the skull. The pins have to be placed over the thicker portions of the skull to prevent skull penetration and the pressure of the pins against the skull must be set accurately to maximize fixation without penetration. The pressure of the pins is determined by the torque or rotational force applied to the pins. All halo systems use some sort of torque wrench to set the pin pressures. All halo systems make an expensive pre-calibrated torque wrench. Some halo systems also include a disposable torque wrench which is much less expensive. The disposable torque wrench is designed for use through the lifespan of one halo system. The Bremer halo system was first to utilize a break-away torque cap for initial application and 24 hour follow-up. The cap will sever from the pin once 8 inch pounds of torque is reached. The Ace halo system uses a disposable strip with a series of square holes which deform when the proper torque is reached. Yet a third system, the PMT system, uses a disposable key which deforms when proper torque is reached.

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APPLICATION OF THE HALO TO THE PATIENT

With every patient's needs and physical attributes unique, the experienced orthotist must take many factors into consideration to maximize the control and minimize patient discomfort that can result from the use of the halo orthosis. It is important that the orthotist understands the patient's condition and that he and the patient's doctor work closely together to optimize the of the halo system.

CROWN OR RING APPLICATION

The first step in applying the crown or ring is to measure the circumference of the skull at equator or that part of the skull with the largest diameter. Then choose a ring or crown with a finger's breadth (1 cm – 2cm) distance from skull at pin application points. A ring or crown that is too large may allow some pin flexion. Pin flexion may result in pin migration and possible dislocation of the crown. Pin migration can also increase the likelihood of infection at the pin sites.

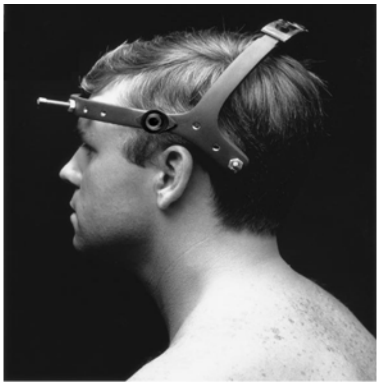

Fig 5. Bremer Crown

The next step is to apply the sterile crown using the temporary placement pins that have suction cupped tips. The orthotists should then check the crown size and determine its position relative to landmarks and the equator of the skull. The ideal ring placement landmarks place the ring about 1 cm above the helix of the ear and 1 cm above the supraorbital rim of the eye socket. (See Fig 5.)

This placement should be below the equator of the skull. The patient's head is shaved around each pin site and scrubbed with betadine or chlorahexane to disinfect the area. To reduce patient discomfort a local anesthetic is injected at the pin sites.

Next, the doctor/orthotist team applies sterile pins, tightening the contralateral pins until they touch, but do not penetrate the skin. At this time, the position of the ring and its distance from the skull at the pin sites are rechecked. Then contralateral pins are tightened finger tight. Next, using a torque wrench or torque caps on the pins, contralateral pins should be tightened by counting half turns to a partner who tightens the same number of turns on the opposite side. The tightening process should continue with alternate anterior right with posterior left pins, then posterior right with anterior left pins until 8 in. lb. of torque (for an adult) are recorded at each pin site.

PIN SITE SELECTION

The criterion used in pin site selection is different in the adult and the juvenile patient and the importance of site selection is greater for anterior pins than posterior pins. Anterior pins should be placed 1 cm superior to the supraorbital rim or eyebrow and cephalic, to the lateral, two-thirds of the orbit. Each pin should be placed below the greatest circumference (equator) of the skull to prevent cephalad migration of the pin.

The anterior pin sites should avoid the temporalis muscle because sitting the pin there may impede mandibular motion and cause the patient unnecessary pain. A pin should not be sited at the temporal fossa because there is only a thin layer of cortical bone there which makes pin migration or skull penetration more likely. Anterior pins should also avoid the supraorbital nerve, supratrochlear nerve, and frontal sinus medial, in order to avoid causing the patient any further discomfort.

The placement of the posterior pins is

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less critical, but ideally these pins should be placed 120 degrees from the midsagital line (bridge of nose). Posterior pins should be approximately diagonal to contralateral anterior pin. Posterior pins should be inferior to the equator of the skull and the ring or crown should be 1cm cephalad to the top of the patient's ear.

Halo use in children is more difficult because their skulls are thinner and children move about more. For these reasons, it is suggested that a CT scan be made of the child's skull to assess thickness at probable pin sites. In patients below 7 years old 8-10 pins should be used. The rule of thumb for children's pin site pressure is one inch/pound per each year of age (therefore a 2 year old child's pins would be tightened to 2 inch/pounds).

APPLICATION OF HALO VEST

The application process begins with the careful measurement of the patient. A circumference at xyphoid level is obtained by slipping a tape measure under the lumbar area of the supine patient and sliding it up to the xyphoid level. The vest may then have to be "presized" if an adjustment to proper xyphoid circumference is required. Some systems have thumb screw fasteners at two inch increments on the posterior vest. If a measurement is between adjustment points, the orthotist should allow the extra inch on the dominant side.

The vest element of the orthosis is fitted to the patient by first placing the patient in an extrication type cervical orthosis to provide temporary cervical support. Then while the doctor holds the patient's head the patient is elevated or log rolled and the posterior shell portion with posterior uprights is slipped under the patient and properly positioned, checking that the uprights are evenly spaced on both sides of the patient's head. Next the patient is laid supine. Then the anterior shell with anterior uprights and lateral bars is placed in proper position on the patient's chest. Next, the lateral bar is connected to the posterior bar and to the ring or crown. All fastenings should remain loose to assess that all upright bars are parallel to each other and the lateral bars are parallel to each other and at the same height on both sides of the patients' skull.

The straps are then connected to the anterior shell at xyphoid level. Next, all of the bolts on the upright, laterals and the ring are tightened using a wrench to firm the entire assembly. Care must be taken to avoid stripping the bolts during the tightening process. One halo manufacturer uses their torque driver, readjusted to 30in. / lbs., to apply the proper torque to the bolts; this helps to prevent stripping of the bolts. Over shoulder straps are next tightened and the position of the vest and cervical spine is checked. The halo pins should be re-torqued to 8 in./lbs (for an adult application) at this time. The lock nuts on the pins are tightened to fix the pins in place and to prevent them from backing out. At the same time, a good anterior -posterior fit between the sternum and the posterior thoracic spine should be checked and adjusted if necessary. With the entire halo assembly now acting as a single unit, the temporary extrication collar is removed and a post-fixation x-ray is taken of the cervical spine.

This concludes the first part of my article on the halo. I have discussed the principal issues that the orthotist must address in fitting a patient with a halo. Careful fitting will overcome many of the problems that can be experienced by patients using the halo. However, due to the often long term use of the halo, problems are inevitable. The next newsletter will discuss problems and their solutions.

Bernardoni Showcases Distraction Helmet at ISCFS

During the last week in September Gene Bernardoni, CO, was honored to participate in the International Society of Craniofacial Surgery (ISCFS) convention in Oxford, UK. Working closely with Dr. McKay McKinnon, a craniofacial surgeon now at Children's Memorial Hospital, Bernardoni has adapted the cranial molding helmet as a foundation from which to provide "distraction", making it possible to hold or enhance corrections in skull shape after reconstructive cranial surgeries.

At the ISCFS convention, Bernardoni, along with Ballert's John Brashler, CO, presented samples of these helmets and discussed their fabrication. Many of the doctors there were familiar with cranial molding helmets used for positional plagiocephaly. There was much interest in this new application for this helmet, which offers a noninvasive distraction system.