The following was received past the deadline for the Spring C.P.O., for which it was intended. Because of the interest in the subject it addresses, we are printing these comments here. Anyone wishing to respond to the points the author raises may do so through letters to the editor. Our thanks to Dr. White for submitting his editorial.

The Editor

Some Comments on Cervical Orthoses

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Introduction

A classic history on the development of orthopaedic appliances, including some interesting material on cervical orthoses, has been written by J. W. Edwards (1952). A reading of this work quickly illustrates that many orthotic devices bear a striking resemblance to components of medieval armor. Particularly prominent in cervical orthotics is the work of Hugh Owen Thomas. This ingenious, chain-smoking, nineteenth century inventor developed a number of useful orthopaedic appliances, and is credited with the basic design of the cervical brace used today and known as the Thomas cervical collar.

Functions of Cervical Orthoses

Any cervical orthosis is really a device designed to apply forces to the cervical spine in order to control it in some way. The goal of that control is usually support, rest, immobilization, protection, or correction. The application of the forces restrains the normal or abnormal patterns of movement or alignment of the cervical spine. When the goal is to rest the spine, the device must assist or substitute for stabilizing muscle action. For example, a cervical collar may be used to prevent extension into a range that is painful or irritating to the patient. In another instance, the purpose of the orthosis may be to protect the vital spinal cord or nerve roots. This would be required when the spine has been rendered unstable by tumor, disease, surgery, or injury. A cervical orthosis can also function simply as a reminder and psychological "support." When the patient moves, he or she is made aware of the brace and therefore voluntarily restricts motion. In addition, the orthosis may provide warmth and physical support that is reassuring to the patient.

After the physician makes a diagnosis, and elects to treat a particular problem with a cervical orthosis, it is helpful to identify the specific mechanical functions that are to be achieved with the orthosis (see Table I). Is the goal to support (rest), immobilize (protect), or correct the spine? It is helpful for the clinician to go through the process of determining which of various motions of the spine must be controlled. Is it flexion, extension, lateral bending, axial rotation, or some combination of these? By thinking through these questions, a more rational and precise orthotics selection can be made.

Table I

Systematic Analysis for the Selection of Orthoses

(1) Determine the goal of orthosis:
- Support (rest, assist)
- Immobilization (protection)
- Correction

(2) Determine how many degrees of freedom are to be altered:
- Flexion
- Extension
- Lateral bending
- Axial rotation
- Axial distraction

(3) Determine the magnitude of control:
- Minimum
- Intermediate
- Most Effective

Orthotics Evaluation Studies

Before discussing examples of cervical orthotics, it is helpful to review briefly the experimental work upon which we base our clinical recommendations. *In-vivo* cineradiographic studies by Hartman and colleagues evaluated the effectiveness of immobilization of various orthotic devices on the cervical spine (Hartman et al. 1975). These studies compared five different cervical orthoses (Findings are shown in Table II). The investigators concluded that the motion that was most difficult to restrain was that between the occiput and C2.

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Table II

Effectiveness of Cervical Spine Orthoses in Immobilization*

Orthoses	Approximate % Restriction of Range of Motion C1-C7					
	Motion Picture			Cineradiograph		
	FE**	LB***	AR†	FE	LB	AR
Soft cervical collar	5–10	5–10	0	0	0	0
Hard plastic collar (Thomas)	75	75	50	75	75	50
Four-poster cervical	80–85	80–85	60	85	85	60
Long two-poster	95	90	90	90	90	90
Guilford two-poster	90–95	90–95	90–95	90	90–95	90
Halo device	Essentially no motion					

*Based on data from Hartman, J.T., Palumbo, F., and Hill, B.J.: Cineradiography of the braced normal cervical spine. *Clin. Orthop.*, 109: 97, 1975.
**FE: Flexion/extension (x-axis rotation)
***LB: Lateral bending (z-axis rotation)
†AR: axial rotation (y-axis rotation)

An evaluation of cervical braces by Johnson and colleagues placed normal subjects in different orthotic devices (Johnson et al. 1977). Photographs and radiographs were used to determine differences in range of motion with and without the subjects wearing various orthoses (Findings are shown in Table III). It was found that by increasing the vertical length and the rigidity of a given cervical orthoses, there is improvement in its ability to control motion. In general, it was found that controlling lateral bending and axial rotation is more difficult than controlling flexion/extension. The most effective conventional braces are able to restrict C1-C2 flexion extension by only 45% or normal. The halo apparatus restricts the motion by 75%.

In summarizing this experimental data, the following generalizations are valid. The soft collar does little in the way of immobilizing the cervical spine. The rigidity of the components at the chin and the occiput are the main elements in restricting motion. As one adds shoulder or thoracic fixation to the various conventional cervical collars, the immobilizing capacity of the orthosis is increased. When the added chest support is actually fixed to the thorax, the immobilizing efficiency is further improved.

Table III

Efficiency of Cervical Braces in Immobilization*

Orthoses	Total Movement From Full Flexion to Full Extension** (degrees)
Soft cervical collar	101
Hard plastic collar (Thomas)	58
Four-poster cervical	25
Duke (occipital, chin, and chest piece)	2

*Based on personal communication with R.M. Johnson
**The median normal is approximately 90 degrees.

Clinical Review of Some Specific Cervical Orthoses

To follow is a review of the major types of cervical orthoses. They are categorized on the basis of *effectiveness of control*. Thus, we have divided cervical orthotics into minimum, intermediate, and most effective control (Table III).

Minimum Control: The basic Thomas collar and numerous variations of it are examples of minimum control orthoses. These collars vary in height, contour and rigidity. They may be worn either forwards or backwards to increase or decrease the amount of flexion/extension possible. Generally, they are to be worn so that the chin rest, which is a convexity in the collar that points downwards, is anterior. However, some patients find it more comfortable to reverse this position, and certainly in cases where one is more interested in restricting extension than flexion, a reversal of this position will block extension more effectively. In other words, if a high portion of the collar is worn posteriorly there is relatively less extension. Although these collars probably do little or nothing in the way of immobilizing the spine, they do provide warmth as well as psychological comfort and support. They can be helpful to the patient in the treatment of a broad variety of conditions including some whiplash injuries, minor sprains and strains, cervical spondylosis, and some stable postoperative surgical constructs.

Intermediate Control: There are a number of orthotics that are appropriately classified in this group. The Philadelphia collar is a beefed-up version of a Thomas collar. It is more rigid, has an anterior and a posterior plastic reinforcement, a rigid chin support, and a significantly developed extension block posteriorly to support and restrict the occiput.

In order to achieve a greater level of immobilization, some extension of the orthosis down into the shoulder and/or thorax is required. This lengthening of the orthosis provides a more effective anchoring, purchase, and immobilization. There are several braces that fit into this category, most notably the four-poster brace, the Duke brace, the Guilford brace, and the SOMI brace. The SOMI is the most effective immobilizer in this group. These orthoses are probably more effective in the standing and sitting positions. In the supine, prone, or side lying positions, relaxation and rotation of the shoulders and thorax minimize the effectiveness of these orthoses.

We should also note that if we wish to prevent anterior displacement of C1 or C2 in a rheumatoid patient we cannot rely upon a soft cervical collar, a Philadelphia collar, a four-poster brace, or even a SOMI brace (Altoff and Goldie 1980).

Most Effective Control: If there is a clinical problem involving significant loss of clinical stability, the cervical orthosis should provide the maximum amount of immobilization, unloading of the spine, and protection. Major control is needed in all of the parameters of motion. Depending on the particular clinical situation, it may be more important to control some particular motion or combination of motions.

One option in this situation is a significantly more rigid version of the Thomas collar. The Minerva cast incorporates the concepts of extending the brace down towards the thorax and immobilizing the chin and occiput. This cast extends from the forehead down to the pelvis. The goddess Minerva was born by popping from the head of Jupiter, fully armored. From this Roman myth the cast has taken its name. This device, although not used very much currently, can be useful, especially in the protection of irresponsible patients. It should be kept in mind, however, that even with a well-applied Minerva cast, a few degrees of cervical spine motion are possible. Most of the motion occurs at the occiput-C1 region. The cast has to be open enough to allow an adequate range of motion for the mouth so that the patient can talk and chew. This same range of motion allows for motion at the occiput-C1-C2 joint complex. Thus, when your patients are in a Minerva cast but can talk and chew, you must be aware that they can move C1-C2.

In difficult clinical situations, where there is extensive disease or surgery, or an injury has rendered the cervical spine unstable, use of a halo apparatus should be considered. This device is fixed to the skull with pins and is attached either to an individually molded plaster jacket or to a prefabricated jacket which comes in several sizes. Experimental studies generally agree that this device is the most effective immobilizer of the cervical spine. One should be aware that use of this device carries the risk of several complications. These include: penetration of the skull by fixation pins, brain abscesses, abducens, glossopharangeal and facial nerve palsy, and the development of cervical spondylosis. Facial complications can be recognized during the first few days after application by requesting patients to smile, roll their eyes, and stick out their tongue. If the patient is unable to do any of these three activities, careful neurological evaluation is indicated.

Resume

A rational approach to the use of cervical orthotics may be taken by posing several questions. What is the clinical condition of the spine? What are the therapeutic goals to be achieved by the brace? Is the goal to protect the spine, or to rest it? In what way should the mechanics of the spine be changed to achieve that goal? What kinds of forces are necessary in order to achieve these therapeutic aims?

In the cervical spine, the standby orthosis for minimal immobilization is the Thomas collar. If one needs a high level of control, then an intermediate zone orthosis, such as the Philadelphia collar or any variety of collars that involve thoracic attachments, can be employed. The SOMI brace is the most effective in this intermediate group. If the therapeutic goal is to obtain maximum control and immobilization of the cervical spine, a halo apparatus with an individually molded plaster jacket is required. One should be aware that this apparatus carries the liability of exposure to complications. These complications can be minimized by diligent care techniques and follow-up evaluation.

References

Altoff, B. and Goldie, I.F.: Cervical collars in rheumatoid atlauto-axial subluxation. A radiographic comparison. *Annals of the Rheumatic Diseases* 39: 485, 1980.

Edward, J.W.: *Orthopaedic Appliances Atlas.* Vol. I, Ann Arbor, Michigan, American Academy of Orthopaedic Surgeons, 1952.

Hartman, J.T., Palumbo, F., and Hill, B.J.: Cineradiography of the braced normal cervical spine. *Clinical Orthopaedics* 109: 97, 1975.

Johnson, R.M. et al.: Cervical orthoses. A study comparing their effectiveness in restricting the cervical motion in normal subjects. *Journal of Bone and Joint Surgery* 59A: 332, 1977.

O'Brien, J.P.: The halo-pelvic apparatus. A clinical, bio-engineering and anatomical study. *Acta Orthopaedica Scandinavica* 163 (supplement), 1975.

Victor, D.I., Bresnan, M.J., and Keller, R.B.: Brain abscess complicating the use of halo traction. *Journal of Bone and Joint Surgery* 55A: 635, 1973.

White, A.A. and Panjabi, M.M.: *Clinical Biomechanics of the Spine*, Philadelphia, J.B. Lippincott, 1978.