Neuroscience 255 (2013) 226–232

VISUO-PROPRIOCEPTIVE INTERACTIONS IN DEGENERATIVE CERVICAL SPINE DISEASES REQUIRING SURGERY

S. FREPPEL,[a,b] A. BISDORFF,[a,c] S. COLNAT-COULBOIS,[a,d] H. CEYTE,[a,e] C. CIAN,[e] G. GAUCHARD,[a] J. AUQUE[d] AND P. PERRIN[a,f*]

[a] *Université de Lorraine, EA 3450 DevAH – Development, Adaptation and Disadvantage, Faculty of Medicine and UFR STAPS, Nancy, France*

[b] *Department of Neurosurgery, University Hospital, Groupe Hospitalier Sud Réunion, Saint Pierre, Reunion Island, France*

[c] *Department of Neurology, Centre Hospitalier Emile Mayrisch, Esch-sur-Alzette, Luxembourg*

[d] *Department of Neurosurgery, University Hospital of Nancy, Nancy, France*

[e] *The Institut de Recherches Biomédicales des Armées, La Tronche, France*

[f] *Department of Oto-Rhino-Laryngology, University Hospital, Vandoeuvre-lès-Nancy, France*

Abstract—Cervical proprioception plays a key role in postural control, but its specific contribution is controversial. Postural impairment was shown in whiplash injuries without demonstrating the sole involvement of the cervical spine. The consequences of degenerative cervical spine diseases are underreported in posture-related scientific literature in spite of their high prevalence. No report has focused on the two different mechanisms underlying cervicobrachial pain: herniated discs and spondylosis. This study aimed to evaluate postural control of two groups of patients with degenerative cervical spine diseases with or without optokinetic stimulation before and after surgical treatment. Seventeen patients with radiculopathy were recruited and divided into two groups according to the spondylotic or discal origin of the nerve compression. All patients and a control population of 31 healthy individuals underwent a static posturographic test with 12 recordings; the first four recordings with the head in 0° position: eyes closed, eyes open without optokinetic stimulation, with clockwise and counter clockwise optokinetic stimulations. These four sensorial situations were repeated with the head rotated 30° to the left and to the right. Patients repeated these 12 recordings 6 weeks postoperatively. None of the patients reported vertigo or balance disorders before or after surgery. Prior to surgery, in the eyes closed condition, the herniated disc group was more stable than the spondylosis group. After surgery, the contribution of visual input to postural control in a dynamic visual environment was reduced in both cervical spine diseases whereas in a stable visual environment visual contribution was reduced only in the spondylosis group. The relative importance of visual and proprioceptive inputs to postural control varies according to the type of pathology and surgery tends to reduce visual contribution mostly in the spondylosis group.

Key words: cervical proprioception, degenerative cervical spine diseases, surgical treatment, static postural control, postural sensorimotor strategies.

INTRODUCTION

Postural control is achieved through a multisensory control mechanism involving visual, vestibular and somatosensory information (Massion, 1992; Gangloff and Perrin, 2002). These inputs are all interconnected allowing compensation of dysfunctions but making it very challenging to study the cues of one particular system without the interference of another.

The sensory contribution to postural control was studied by various experimental paradigms. Several authors (Wolsley et al., 1996; Thurrell and Bronstein, 2002) showed that an optokinetic stimulation induced a visually evoked postural sway. Others have shown the contribution of cervical proprioception to postural control by the vibratory method. Indeed a vibration applied to the neck, through the stimulation of receptors in cervical muscles, can induce a postural response (Roll and Roll, 1988; Bove et al., 2001, 2002; Dumas et al., 2013) by modifying the perception of the head or whole body orientation (Biguer et al., 1988; Taylor and McCloskey, 1991; Ceyte et al., 2006).

Analysis of postural control of patients with posttraumatic cervical pain is a good example of the challenging difficulty, in a pathological condition, to study solely one type of sensory information. There is clear evidence of postural control impairment in patients with whiplash injuries (Treleaven et al., 2003) but the sole responsibility of cervical proprioception has never been demonstrated as vestibular or vertebral artery lesions can also occur during deceleration (Brandt and Bronstein, 2001).

Degenerative cervical spine diseases have raised far less interest when it comes to proprioception and postural control despite being initially suspected as a probable cause of the controversial ‘‘cervical vertigo’’ (Ryan and Cope, 1955). Considering the high prevalence of these pathologies, their current

*Correspondence to: P. Perrin, EA 3450 DevAH – Développement, Adaptation et Handicap, Université de Lorraine, UFR STAPS de Nancy, 30 rue du Jardin Botanique, 54600 Villers-lès-Nancy, France. Tel: +33-3-83-15-49-68.
E-mail address: philippe.perrin@univ-lorraine.fr (P. Perrin).

Abbreviations: CCRM, counterclockwise rotary motion; CRM, clockwise rotary motion; EC, eyes closed situation; EO, eyes open situation; RQ, Romberg quotient; VKQ, visual-kinetic quotient.

0306-4522/13 $36.00
http://dx.doi.org/10.1016/j.neuroscience.2013.09.060

representation in posture-related scientific literature seems inadequate. Posture and cervical proprioception have been studied in cases of non-traumatic neck pain regardless of a potential underlying degenerative spine disease (Revel et al., 1994; Field et al., 2008; Pinsault et al., 2008). A few studies of the degenerative spine focus on vertigo and decreased blood flow velocity in the vertebral artery (Cevik et al., 2010; Machaly et al., 2011).

There are, so far, only three reports on impaired postural control in patients with cervicobrachial pain and objective, radiological signs of degenerative cervical spine disease (Vitte et al., 1992; Karlberg et al., 1995; Persson et al., 1996). The postural effects of degenerative spine disease and surgical treatment were studied but solely in perturbative conditions (vibratory stimulus to the calf and paraspinal neck muscles or bipolar binaural galvanic stimulation). These stimulations are not frequently encountered outside of a research laboratory. The effects of degenerative cervical spine disease and its surgical treatment on unperturbed postural control remain unknown.

Moreover, there are two different types of degenerative spine diseases. A disc herniation usually has an acute onset whereas spondylosis is a chronic disease in which age-related degenerative changes of the discs and osteophytic bars may narrow the cervical canal or the foramina. The consequences of these two specific diseases on postural control have never been analyzed.

The aim of this study was to evaluate visuo-proprioceptive interactions in the postural control of patients with two degenerative spine diseases by generating an optokinetic stimulation in different head on trunk positions, before and after surgery. Our objectives were to investigate, in cervical spine diseases, the different sensorial strategies in posture and assess their evolution after surgical treatment.

EXPERIMENTAL PROCEDURES

Patient population

Seventeen patients (10 females and seven males) with degenerative cervical spine disease, age range from 35 to 75 years (median age 50 years, interquartile range 10.5 years) were recruited. All experiments were conducted in accordance with the Declaration of Helsinki and all patients gave written informed consent to participate in the study. Exclusion criteria were: history of neurological, spinal or inner ear disease and signs of myelopathy on clinical examination or imaging. All patients consulted initially for radiculopathy resisting medical treatment and required surgery. None of them complained of dizziness or vertigo.

Radicular compression was caused by spondylosis for nine patients (four females and five males, median age 51 years) and by a herniated disc for eight patients (six females and two males, median age 47.5 years). The patient population was therefore divided into a spondylosis group and a herniated disc group. In the spondylosis group, four patients required surgery on one level, four patients on two levels and one patient on four levels. In the herniated disc group, seven patients required surgery on one level and one patient on two levels.

Control population

Thirty-one individuals, age range from 26 to 60 years (median age 45 years, interquartile range 15.5 years) were recruited among the medical and paramedical staff and included in a control group. This control group will be used as a reference to evaluate the influence of cervical degenerative diseases on the patient population in a preoperative session. All experiments were conducted in accordance with the Declaration of Helsinki and all subjects gave written informed consent to participate in the study. Individuals with a history of neurological, spinal or inner ear disease were excluded from the control group.

Platform

Data were collected on a vertical force platform (Medicapteur, Nice, France) mounted on three strain-gauge force transducers, providing a measurement of the body sway in terms of displacement of the center of foot pressure (CoP) in a two-dimensional horizontal plane with a sampling rate of 40 Hz. Data were analyzed with the Winposture 1.62 software.

Roll optokinetic stimulation

The visual display consisted of a large cupola (1 m diameter) positioned 25 cm from the subject at eye level, such that it covered a large area of the subject's visual field (visual angle 127°). This cupola was covered in randomly distributed color circles of different diameters and could be rotated around the visual axis at an angular velocity of 50°/s either clockwise or anti-clockwise (Fig. 1).

Surgery

All patients required surgery. In our institution, patients with spondylosis benefit from a Cloward procedure (Cloward, 1958) whereas patients with herniated disc will benefit from an arthroplasty. In both cases, the intervertebral disc is removed through a right anterior approach whether the radiculopathy is located on the right or on the left side. The skin and the platysma are incised. The right sternocleidomastoid muscle is retracted laterally and the carotid and esophagus are separated to expose the cervical spine. Both *longus colli* muscles are partially cauterized, cut and dissected from the anterior aspect of the vertebral bodies. The disc and both anterior and posterior common vertebral ligaments are removed. Both left and right nerve roots of the pathological level are decompressed.

In the case of a Cloward procedure, a polyether ether ketone (PEEK) cage filled with spongious bone chips harvested on the iliac crest is placed in the intervertebral space in order to obtain fusion of the adjacent vertebras.