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BIOMECHANICS OF LUMBAR BACK PAIN IN DENTISTRY

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Abstract: *Chronic low back pain is one of the most common ailments causing disability in the dentistry area. The aim of the present study is to find out how the lumber spine can be damaged during the use of an incorrect working posture at the workplace over a prolonged period of time and what can be done to improve ergonomically the dentist workplace in order to eliminate the back pain. To do so, we gather information about the lumbar spine mechanical properties, and try to develop a mathematical model to construct an mechathronic device which will simulate the relative movements between the vertebras and offer information about the inter vertebral pressure, which usually cause low back pain.*
Key words: *ergonomics, biomechanics, back pain, lumbar spine*

1. INTRODUCTION

Dentists have a high incidence of occupational back pain and injury, in some cases making it impossible for them to continue to work as dentists.

The nature of dental work means flexion of the lumbar spine and subsequent loading on inter vertebral discs or extra tension in the spinous ligaments both of which can contribute to discomfort and pain.

Mechanisms of trauma are dealt with only briefly because they are not of widespread interest, and there is little scientific work to support the classifications of injuries that are currently accepted. On the other hand, a great deal of effort has been spent on trying to understand the origins of limited structural failure in spinal tissues, because such failure is extremely common, is linked to back pain and tissue degeneration, and may be both preventable and treatable.

Not every case of back pain means that is damage in the tissues, and many have no detectable spinal pathology of any kind. Evidence is mounting that mechanical back pain can arise directly from high, but non-damaging, stress concentrations within innervated tissues.

A review of the literature documenting back/neck pain in dentistry has found that there are multiple areas of investigation. These include; firstly, the risk of dentists developing neck/back pain in the first place, secondly, the prevalence of back pain among the dental profession (including dental students), thirdly, the various treatments for back pain prescribed by physicians and, lastly, the various alternative therapies that can be provided by those working in such areas e.g. acupuncture.

A number of studies have examined the ergonomics issues associated with dentists and surgeons. Most of this work has focused on the symptoms experienced by dentists, perhaps because of their repetitive daily activity patterns when treating patients.

Back pain is one particularly crucial problem that is in a dentist's best interest to avoid. A good seating position and correct posture is vital for the efficient practice of dentistry and to avoid chronic back pain. In order to do this, it is important to begin learning the correct posture to use while treating patients early in the dental career. A recent study has however concluded that body pain is prevalent even among dental students. *Reports of body pain in a dental student population* Rising, David W. DMD et al JADA Vol 136, Jan 2005, 81-86.

It has been found that the constant replication of certain movements, such as the many movements that a dentist will perform whilst treating patients in general practice, can contribute to chronic body pain. Rising and David describe how dentists experience more back pain than the practitioners in other occupational groups.' (Rising, David W. et al. 2006).

The authors conducting this study also aimed to estimate the prevalence and locate the site of body pain that was experienced by the selected dental students. The results showed that 'chronic musculoskeletal pain can appear early in a dental career, with more than 70 percent of dental students of both sexes reporting pain by their third year.' The study also showed that 'men reported having worst pain in their mid- to lower back.'

The treatment of back pain varies greatly and is often specific to the individual's symptoms. The conventional methods include: painkillers, back manipulation and remaining at work. These are the recommendations from 'Clinical Guidelines for the Management of Acute Low Back Pain, Royal College of Surgeons 1999'.

Another study, which showed an increased confidence in alternative therapies for the treatment of back pain, indicates 'most respondents indicated they would be "very likely" to try acupuncture, massage or chiropractics for their back pain if they did not have to pay extra money for it and their physician thought it was a reasonable treatment option', illustrating that some people may not be able to afford unproven alternative therapies (Sherman et al. 2004).

The aim of the current study is to determine the load and defective positions dentists adopt, that triggers the pain and the degeneration of the tissues in the lumbar spine.

2. MATHEMATICAL MODEL

Mathematical models of the spine depend on material properties obtained from cadaver experiments, and so incorporate the same post-mortem artifacts. In addition, they are obliged to make simplifying assumptions regarding the mechanical behavior complex fiber-reinforced composite materials such as the anulusfibrosus. Analytical models must simplify spine anatomy, often to an unrealistic degree. This can be overlooked if the purpose of the model is merely to demonstrate some mechanism in a qualitative manner (e.g. to show that any reduction in nucleus volume will lead to increased radial bulging of inter vertebral discs) but simplification becomes a problem if the model is used for quantitative predictions (for example, the angle at which the anulusfibres become damaged in torsion). Finite element models are able to represent the anatomy correctly, but for some reason, many of them concentrate on upper lumbar levels so their conclusions may not be applicable to the wedge-shaped L4-L5 and L5-S1 discs which are of most clinical interest. The precise shapes and spacing of the opposing zygapophysial joint surfaces have a critical effect on the predicted contact stresses, and even finite element models must approximate these shapes and spacing from limited cadaveric material. Evidently, the mathematical modeler can choose between a wide variety of assumptions, material properties and shapes, until the output of the model appears ‘reasonable’, so the models have little true predictive power. However, they are able to explore internal mechanism that would be difficult to verify experimentally, and they can examine how inter vertebral discs functions depends on variable factors such as height and water content. Another problem with most finite element models is that they are constructed using averaged geometrical and material properties, so they are unable to predict the diversity of mechanical behavior encountered in different spines, and which may be of clinical interest. Some modelers have taken diversity in geometrical and material properties into account in order to reduce this problem.

3. MEASURING STRESS DISTRIBUTION INSIDE INTERVERTEBRAL DISCS

‘Stress profilometry’ has revealed the internal mechanical functioning of the discs to an unprecedented extent, both in vitro and in vivo. Because of its importance, it is appropriate to consider briefly how it is performed, and what is actually being measured.

A static compressive load, sufficient to simulate light manual labor, is applied to a motion segment for a period of 20s, and during this time, the distribution of compressive stress within the discs is measured at a frequency of 25HZ by pulling a miniature pressure transducer through it, along its sagittal mid-line. The transducer is a small 2mm long strained gauged membrane mounted in the side of a 1.3mm diameter needle. The annulus has excellent self-healing properties and no disc material is expressed through the needle-hole during the experiments. Rotating the needle about its long axis enables the vertical and horizontal components of compressive stress to be measured in successive tests, using the same needle track.

Validation tests have shown that the output of the transducer in most regions of the disc is approximately equal to the average compressive stress acting perpendicular to its membrane. This implies that there is negligible resistance to the matrix deforming into the slight recess in the needle to press on the transducer membrane. The outer 2-4mm of annulus is a fibrous solid in which there is unlikely to be sufficient ‘coupling’ between matrix and transducer membrane for reliable recordings to be made. Note that there may be high tensile forces in the collagen fibers in this region of the disc, but the transducer does not detect these. The transducer output represents an average stress acting on the 2mm long membrane, and this may help to explain why measured compressive ‘stress’ usually falls steadily to zero near the disc periphery.

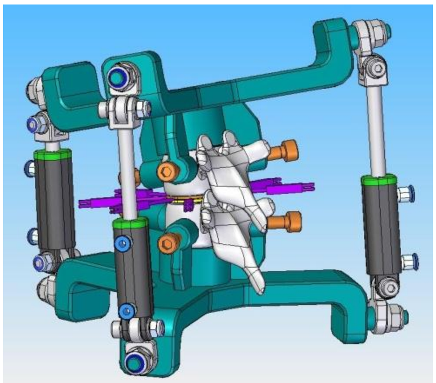

Fig. 1. Mechathronic device that simulates the relative motion between two lumbar vertebras and measures the inter vertebral pressure.

4. CONCLUSION

Changes in operating methods in dentistry, which have occurred since the late 1950s, have altered the occupation from a standing to a sitting profession. Shugars found that good posture correlated negatively with back pain and, generally, dentists who sat 80% to 100% of day reported more frequent lower-back pain. Static work in the sitting posture requiring spinal flexion and rotation has been associated with increased risk of low back pain (Shugars et al.1984).

According to Visser and Straker since the introduction of the sitting posture, lower-extremity problems of the worker have decreased, but musculoskeletal injuries of upper extremities and the low back have not been eliminated (Visser & Straker. 1994).

Loads on soft-tissue structures of the lumbar spine and discs are increased by sitting. Standing can serve as micro break and helps to prevent and alleviate low-back pain.

Suiting should occur in a chair with lumbar support, not on a stool. The lumbar support has to be comfortable; it should fit to lumbar curvature, and contact should be maintained with it while the health care provider is sitting.

Compromise of the straight spine position results from leaning forward to improve visibility or because the patient is located too far away.

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