

Loss of cervical lordosis: What is the prognosis?

ABSTRACT

Neck pain is a diffuse problem with a high incidence and often leads to the more or less appropriate prescription of imaging studies of the cervical spine. In general, this is represented by a magnetic resonance imaging (MRI) scan. Frequently such studies reveal no other significant findings apart from a loss of cervical lordosis either under the form of a simple straightening of the spine or even an inversion of the normal curvature into a kyphosis. Faced with this entity, the clinician is put in front of a series of questions: to which extent such a finding plays a role in the patient's symptoms? If it does what is the role of conservative or even invasive treatment? What are the implications for surgery either for decompressive procedures or corrective procedures? To shed some light on these questions, the authors present a narrative review of the most relevant literature on the topic. Papers examined span from the initial epidemiologic reports out of the pre-MRI and computerized tomography era up to the most recent discussions on cervical sagittal alignment and its implications both for the surgical and nonsurgical patient. In this process, it becomes increasingly clear that we are still far from making any definite statements.

Key words: Cervical spine; clinical correlation; sagittal alignment.

Introduction

Neck pain is a common health problem and increasingly relevant in health-related quality of life (HRQOL) not only in the industrialized countries. Numbers available report that 70% of adults suffer from it at some time in their lives^[1,2] while 10%–40% of adults are bothered by neck pain each year.^[3] Chronic neck pain that had persisted more than 6 months in the previous year is reported by 10%–15% of adults. In terms of prevalence, in the population over 40 years of age, 20% experience neck pain out of which 5% of disabling intensity.^[1]

Considering these numbers, it is quite clear that a vast amount of imaging studies are performed for neck pain at any given moment even in countries where the health authorities are continuously trying to reduce and refine the prescription criteria.

In general, the imaging modality of choice in the absence of trauma is magnetic resonance imaging (MRI). Considering that patients are and wish to be increasingly informed in depth about their health status and its ramifications, discussions of the single aspects of imaging findings often

start already at the primary care level. In the case of neck pain and the respective cervical MRI scan performed for its assessment, the finding of loss of cervical lordosis (even though reliable measurements should be performed on standing lateral radiographs) [Figures 1 and 2] can raise a number of questions. These require either appropriate reassurance or the explanation of the need for treatment, further investigations, or future implications of the finding.

The authors, therefore, performed a review of the literature in an attempt to find the most appropriate answers to the questions that will be examined in the following sections:

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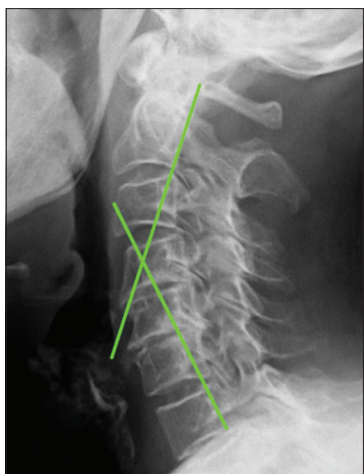


Figure 1: Lateral projection of a cervical spine radiograph. The lines indicate the posterior tangent measurement technique for cervical lordosis. The value is in the angle formed by the intersection of the lines

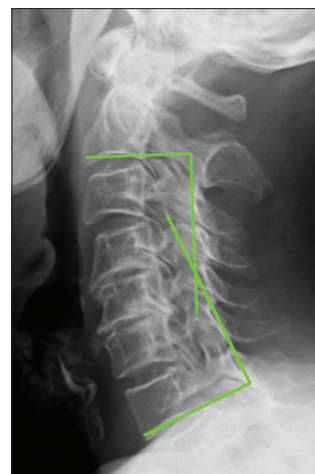


Figure 2: Lateral projection of a cervical spine radiograph. The lines indicate the perpendicular planes to the measured vertebral end plates for the measurement according to Cobb. The angle is determined by the intersection of the perpendiculars

What is the correlation between loss of cervical lordosis and present clinical picture? What is the impact of therapeutic measures on cervical curvature? How important is cervical alignment in the context of surgery, either as a postoperative complication or a postoperative outcome measure in corrective procedures?

Loss of Cervical Lordosis: Implications for the Patient with Neck Pain

The first papers on the dynamic or cineradiographic behavior of the cervical spine appear in the early 1950s.^[2,3] Quantification of what could be a normal cervical lordosis spans through the 1960s and the discussion on the prevalence and significance of an altered cervical curvature probably begins with the work of Weir, who in the early 70s perform a study on the roentgenographic findings of cervical injury. In the course of this study, it is found that around 20% of the asymptomatic population present an alteration of either straightening or inversion of cervical lordosis.^[4]

Gore *et al.*, in 1987, present what appears to be the first longitudinal observational study on the topic reporting on over 200 patients that had been followed for 10 years since their first presentation for neck pain. At follow-up, they find no correlation between clinical improvement and the presence of degenerative changes, changes in spinal canal diameter or changes in lordosis.^[5] In a subsequent paper, the authors conclude that there appears to be a correlation between degeneration of the C6 and C7 segment and future development of neck pain. It is, however, not elaborated on as to what could be the mechanism underlying such a correlation.^[6]

These results and others are reviewed around 5 years later by Gay, who on the question whether cervical spine curvature has any significance or influence on clinical evolution conclude with a no.^[7]

In 1994, Helliwell *et al.* performed a cross-sectional study on the prevalence of “straight” cervical spines in three populations to assess whether there would be any correlation between loss of lordosis and muscle spasms. One group had acute posttraumatic neck pain, one chronic neck pain, and another group was made up of healthy controls. Interestingly “straight” cervical spines were more frequent in the chronic and healthy groups as opposed to the acute postinjury group.^[8]

In 1997, Hardacker *et al.* present a study of radiographical analysis of 100 healthy volunteers without neck pain. This group was divided into individuals with low back pain and no low back pain. The novelty of this study is that the authors examine the alignment of the cervical spine in a whole spine standing context. Images were taken on long cassette films, and besides cervical curvature also data like vertical alignment (SVA) was assessed. The authors conclude that in all individuals, the SVA of the odontoid over either C7 or the sacrum falls into a quite narrow range, indicating thus the overall balance of the examined subjects. However, even in this globally balanced setting, cervical lordosis was present in almost 40% of individuals. It has to be said, however, that in this case, segmental kyphosis is concerned, whereas overall kyphosis was present in only 4% of subjects.^[9]

In 1998, Matsumoto *et al.* publish a paper, in which they compare cervical curvature between two groups of almost

500 subjects each, of which one is composed of asymptomatic volunteers and the other of acute whiplash injury patients. Both groups show no statistical difference in the prevalence of altered cervical curvature.^[10]

Almost another 10 years after this paper, in 2007, Grob *et al.* pick up the question again and carry out a radiographical study on over 100 individuals.^[11] Half of these have neck pain and the other half not. The authors perform standard lateral cervical X-rays and find no difference between the two groups as far as curvature of the spine is concerned. They conclude that according to their findings abnormalities of the cervical curvature in a neck pain patient should be considered coincidental. The authors present a standardization of the performance of the lateral cervical X-ray, in which all patients have their head posture oriented along a line projected on the orbitomeatal plane. Furthermore, they mention the limitation that the cervical curvature was evaluated in an isolated manner and not in the context of a whole spine X-ray, hence suggesting that in this manner, any reciprocal influence of the separate spine regions on each other remains obviously undetermined. Considering, however, the study by Hardacker *et al.* 10 years prior, where these relations had been examined showing no significant interrelation, this probably represents no shortcoming of any significance.

Finally, another study, which appears to be the most recent one, is yet another confirmation of the lack of significance of cervical curvature on the clinical picture. In 2014, Kumagai *et al.* publish a study on over 700 volunteers measuring cervical lordosis and investigating on its significance.^[12] They conclude that the sagittal alignment of the cervical spine was not associated with neck symptoms, but degenerative changes were associated with the severity of neck pain in females.

Considering the number of observational studies, some of them longitudinal, it would thus appear that we are far from being able to make any inferences on the clinical condition and/or the fate of the patient who presents with loss of cervical lordosis. This analysis is, however, not complete if we do not consider what appears to be the only group of authors that identifies a correlation between cervical lordosis and neck pain. Harrison *et al.* have been quite active on the subject since the mid-1990s, with a series of publications ranging from the presentation of a posterior tangent method for measuring lordosis up to an observational radiographic study on the prevalence of lordosis in neck pain patients and outcomes of treatment for correcting cervical hypolordosis.^[13,14]

In 2005, McAviney *et al.* publish a study in which almost 300 cervical X-rays were examined after dividing the subjects into groups with and without cervical pain. The authors conclude that they found a statistically significant association between cervical pain and lordosis $<20^\circ$ and a “clinically normal” range for cervical lordosis of 31° – 40° . They, therefore, suggested that maintenance of a lordosis in the range of 31° – 40° could be a clinical goal for chiropractic treatment.^[15]

This brings us to the question whether conservative management can have a role in neck pain in the presence of cervical straightening by acting on restoration of a “normal” lordosis.

Considering that most studies show no correlation between lordosis and pain, there is obviously little available in the literature regarding the topic. Moustafa *et al.*, in line with their findings, appear to be the only group that continues to devise methods for the restoration of cervical lordosis as a means to improve neck pain and related disability. In an interesting recent study, they randomized 72 neck pain patients with cervical hypolordosis and anterior head translation to receive either standard treatment or treatment plus the adjunct of a traction associated with a cervical roll. Improvement was found in both groups but more sustained in the experimental group with better lordosis restoration. They conclude that appropriate physical therapy rehabilitation for cervicogenic dizziness should include structural rehabilitation of the cervical spine (lordosis and head posture correction) as it might lead greater and longer lasting improved function.^[16]

Another recent study however that performed both measurements of cervical lordosis and studied the effects of spinal manipulation on cervical lordosis again found no correlation. Shilton *et al.*, in 2015, compared cervical lordosis in thirty healthy controls and thirty pain patients and carried out spinal manipulation on the pain patients with subsequent remeasuring of the cervical curvature. They conclude that no difference in cervical lordosis (sagittal alignment) between patients with mild nonspecific neck pain and matched healthy volunteers could be found. Furthermore, there was no significant change in cervical lordosis in patients after 4 weeks of cervical spinal manipulation therapy.^[17]

Loss of Cervical Lordosis: Implications for the Patient Undergoing Surgery

For the surgical patient, two types of consideration need to be made regarding cervical alignment: One is about the implications of possible kyphosis following posterior

decompressive surgery, namely, laminectomy without fusion, and the other is about the patient with kyphosis, either iatrogenic or else, who needs to undergo surgery for correction.

In the first scenario, the question is whether the surgical procedure favors the development of kyphosis, and if yes, what the clinical implications are, and in the second scenario, the question is if there is anything like an ideal curvature that should be reconstructed to obtain maximum clinical benefit.

As far as, the first issue is concerned Kaptain *et al.* evaluated preoperative and postoperative sagittal alignment in 46 patients undergoing cervical laminectomy finding a 2-fold greater rate of postoperative kyphosis for patients with preoperative “straightened” cervical spinal alignment.^[18] However, no correlation between change in sagittal alignment and neurologic outcome could be determined. Similarly, Kato *et al.* found postoperative progression of kyphotic deformity in 47% of patients although there was no correlation with neurologic deterioration.^[19] Mikawa *et al.*, in a study, on over sixty patients treated with multilevel decompressive laminectomy without fusion found the development of kyphosis in 14% of patients and conclude that extensive laminectomy, even including the C2 lamina, seemed to have no adverse effect on the stability of the cervical spine, and no patient needed to undergo a second operation for deformity or deterioration.^[20]

This issue is different in the pediatric patient population with a higher incidence of postlaminectomy kyphosis in over 50%–100% of cases treated as reported in different series.^[21]

It would thus appear that at least in the adult population postlaminectomy kyphosis is a common finding, but it does not seem to have any significant clinical repercussion.

When it comes to surgical decision-making in front of a kyphotic cervical spine, either iatrogenic or not, the issue is somewhat more intuitive. Restoration of a harmonious spinal curvature, especially in long segment fusion procedures appears to be of importance and as far as the thoracolumbar spine is concerned has also extensively been studied and demonstrated.^[22-24]

In the cervical spine, however, studies attempting to identify the ideal cervical curvature are rather scarce. Both anterior and posterior procedures on the cervical spine have a potential to greatly modify sagittal alignment, especially in the anterior procedures where even short segment

standard operations can remarkably influence cervical lordosis [Figure 3].^[25,26] Are there any particular indications to be given in these cases?

Most certainly, the chin-brow to vertical angle (CBVA), i.e., the angle that is formed on a lateral view between a vertical line and a line that goes from the chin to the eyebrows or superior orbital rims, is of absolute importance as it determines whether the subject can look straight ahead or not [Figure 4]. Thus, whenever working on the reconstruction of a cervical curvature, including other spinal regions or not, this should be accounted for with a tolerance from 10° to 10°.^[27]

However, while this is again intuitive, various authors have proposed other measurements to put the cervical spine into a more global context, thus linking it to other parameters in an attempt to extrapolate interrelations between spinal segments and identifying how they might harmonize with each other for a correct global posture and better clinical outcome.^[28-33]

Only a few studies have yet attempted correlations between certain parameters and HRQOL measures. Among these, Tang *et al.*, in a retrospective analysis, of 113 patients operated with posterior cervical fusion demonstrated that a C2–C7 sagittal vertical axis (SVA) >4 cm correlated with increased disability in patients following posterior cervical fusion procedures.^[34] Similar results were found by Roguski *et al.*, who studying a small cohort of patients randomized for either anterior or posterior cervical surgery found that a C2–C7 SVA of more than 4 cm would correlate with worse clinical outcome.^[35]

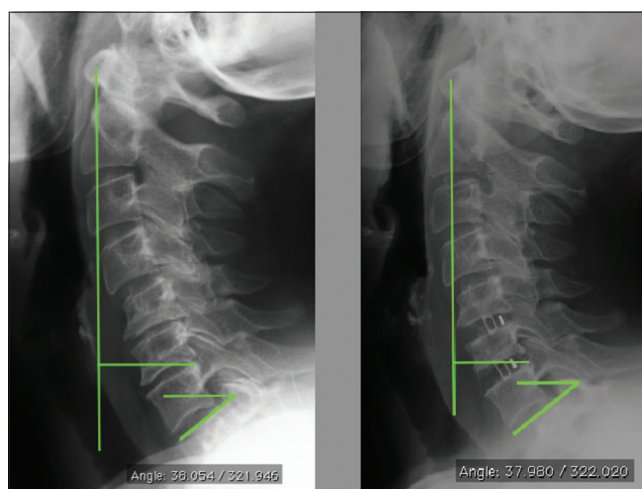


Figure 3: Lateral projection of a cervical spine radiograph. On the left preoperative image and postoperative on the right. Note the C1–C7 plumb line and their change after two-level anterior cervical discectomy and fusion with interbody cages. Note the angle indicating the slope of T1. This angle has to be identical to guarantee comparison between measurements



Figure 4: Lateral photograph showing the chin-brow to vertical angle

Apart from this, number and similar statements in other papers, we could find no firm indications and correlations on this topic.

Discussion and Conclusions

The possibility to correlate clinical outcome with alignment of the spinal column seems appealing but is, however, not as easily translatable into practice as it might seem. Boden *et al.*, in their landmark papers at the beginning of the 1990s on the correlation between imaging findings on spinal MRIs and clinical status, showed us how important it is to treat the patient and not the images.^[36,37] While the lack of correlation between degenerative changes such as disk protrusions, stenosis, and spondylosis, in general, was therefore quite compellingly showed, some years later, a new movement started that tried to put into relationship imaging findings with clinical outcomes. This was the definition of pelvic incidence and its correlation with the entire sagittal spinal alignment.^[38] Quite quickly, many papers were published that showed how indispensable it is to recreate a certain spinal alignment to obtain maximum clinical benefit. This started with the lumbar spine, but also here limitations start to appear,^[39] and is currently attempted for the cervical spine where we are, however, still far from making any particular extrapolations. Up to now, all that can be said about alignment in the cervical spine is that what seems logical in any way and most of all serves a purpose. Restoration of an adequate CBVA is as important and intuitive as restoration of alignment at the atlantoaxial level for the treatment of basilar invagination.^[40,41]

For everything else, it is surely difficult to find definite answers considering that pain as a biopsychosocial phenomenon is probably too vast a problem to be simply reduced to any kind of measures, no matter how sophisticated and appealing such a computation may be.

Nevertheless, studies that continue to correlate as many objective parameters as possible with HRQOL measures are surely indispensable. To propagate data collection and insights in this direction, every spinal practitioner, conservative or surgical, should therefore familiarize with and apply such measurements and perform, wherever possible, X-ray studies of the whole spine to gain increasingly deeper understanding of the interplay between the spinal regions much rather than looking at a single region on its own.

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Conflicts of interest

There are no conflicts of interest.

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