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Is the C2 slope a reliable indicator of decompensated spinopelvic alignment? A Sacro Occipital Technique perspective

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Abstract

Purpose: To investigate the relationship between C2 slope and pelvic tilt and provide clinicians with an additional radiographic parameter for evaluating global spinal balance using routine lateral cervical imaging.

Methods: Incorporating cervical analysis into full-spine evaluations may improve diagnostic accuracy when addressing persistent pelvic imbalance or recurrent postural compensations. For practitioners utilising Sacro Occipital Technique, these findings offer a measurable framework that may support traditional clinical observations regarding the cranial-pelvic relationship.

Conclusions: Assessment of C2 alignment may help identify compensatory postural adaptations that influence pelvic orientation and overall sagittal integrity Further clinical investigation may clarify whether evaluating C2 alignment prior to pelvic category correction could enhance stability and longevity of chiropractic adjustments.

Indexing terms: Chiropractic; spinal adjustment; Sacro-Occipital Technique (SOT), C2 slope, Myodural bridge, cerebral spinal fluid flow, Dural torque.

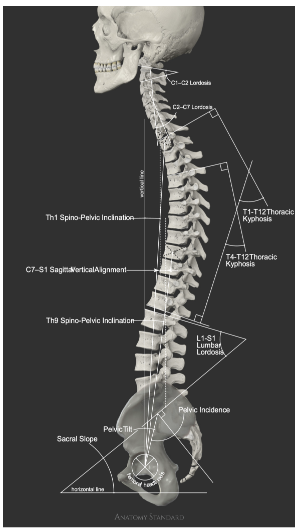

Figure 1

Clinical implications

Recognition of the relationship between C2 slope and pelvic tilt provides clinicians with an additional radiographic parameter for evaluating global spinal balance using routine lateral cervical imaging. Assessment of C2 alignment may help identify compensatory postural adaptations that influence pelvic orientation and overall sagittal integrity. Incorporating cervical analysis into full-spine evaluations may improve diagnostic accuracy when addressing persistent pelvic imbalance or recurrent postural compensations. For practitioners utilising Sacro Occipital Technique, these findings offer a measurable framework that may support traditional clinical observations regarding the cranial-pelvic relationship. Further clinical investigation may clarify whether evaluating C2 alignment prior to pelvic category correction could enhance stability and longevity of chiropractic adjustments

Introduction

A growing body of research has illustrated an intimate connection between the C2 slope and pelvic tilt (PT). (1, 2, 3, 4) One study reports unequivocally that '*C2 slope (C2S) is a critical, easily measured radiographic marker that can be used in cervical sagittal alignment analysis and serves as a simplified, accurate calculation for pelvic tilt (PT)*'. (5) As shown in Figure 1 above, it acts as a vital link between the upper and lower spine and pelvic position, assisting clinicians in the diagnosis of spinal deformity. Furthermore, it has been reported that when the C2 pelvic angle (C2PA) exceeds 13°–16°, it becomes a reliable indicator of decompensated spinopelvic alignment, often correlating with poorer patient-reported outcomes, including lower SF-36 scores and increased pain. (6, 7)

'… contemporary scientific validation should be viewed not as a replacement for earlier insights but as an opportunity to refine and contextualise them within a modern evidence-based framework…'

These findings provide clinicians with a rapid and reliable method for assessing spinal sagittal integrity, often within one degree of accuracy, using only a lateral cervical radiograph. One radiographic study of volunteers with both high and low pelvic incidence demonstrated that, despite extreme variations in pelvic parameters, C2 tilt remained within 1° of L1 pelvic angles. (5)

Reconsidering the earlier observations of DeJarnette within Sacro Occipital Technique (SOT), the pelvis and the head were proposed to be intimately connected. (8) What is remarkable is that these concepts were developed purely through radiographic interpretation and clinical observation, without the benefit of modern imaging software, computational modelling, or advanced statistical analysis. DeJarnette demonstrated a keen understanding of body mechanics and compensatory mechanisms, recognising that a functional relationship must exist between cranial and pelvic structures.

When C2 tilts forward, represented radiographically by an increased C2 slope, the body may compensate by tilting the pelvis posteriorly in order to maintain balance and preserve visual and vestibular cerebellar postural reflexes. This compensation assists the body in maintaining equilibrium in response to gravity. (9)

Several neurological reflexes help explain this C2–pelvic relationship.

The Asymmetrical Tonic Neck Reflex (ATNR)

The Asymmetrical Tonic Neck Reflex (ATNR) contributes to pelvic symmetry during development by linking head rotation (guided primarily by C1–C2 motion) to contralateral limb extension and pelvic shifts. (10)

The Symmetrical Tonic Neck Reflex (STNR)

The Symmetrical Tonic Neck Reflex (STNR) regulates muscular tone in response to cervical flexion and extension. Neck flexion promotes arm flexion and leg extension, influencing sagittal pelvic positioning. (10)

The Cervicocollic Reflex (CCR) and vestibulospinal reflexes

The Cervicocollic Reflex (CCR) and vestibulospinal reflexes stabilise head position, and their neural input modulates lumbar and pelvic musculature. Within this framework, C2 misalignment may disrupt these reflex pathways, potentially leading to compensatory pelvic tilts that help maintain overall postural balance. (11)

The Spinal Galant Reflex

The Spinal Galant Reflex, primarily active in infancy to facilitate pelvic mobility, may also influence hip and pelvic tilt if retained beyond early development. (12)

The cervicolumbar reflex

Additionally, the cervicolumbar reflex involves neural pathways linking proprioceptive input from cervical muscles and ligaments, particularly those near C2, to the lower spine and pelvis. These pathways provide feedforward control, enabling the brain to anticipate changes in pelvic positioning based on cervical posture to maintain balance. (13)

Clinically, Chiropractic techniques have long recognised functional spinal relationships that contribute to postural stability. In SOT, the Lovett Brother phenomenon, described as R + C factors, suggests that vertebral segments function in paired relationships to maintain spinal balance. (14, 15) Within this clinical model, C2 is often considered functionally coupled with L4. In this relationship, C2 may exert a descending influence on L4 positioning, while L4 may exert an ascending influence on C2.

The L4 vertebra also plays an important role in pelvic tilt by influencing the lumbosacral angle. Dysfunction at the L4/L5 segment can contribute to anterior or lateral pelvic tilt, increasing mechanical stress on the lower back and potentially leading to pain. (16) Structural alterations at L4/L5 or L5/S1 may cause the sacral base to become unlevel, producing compensatory pelvic tilt.

From a neuroanatomical perspective, the C2 facet joints, the first true facet joints in the cervical spine, as C1 lacks typical facets, are critical for cervical proprioception. These joints provide essential afferent input regarding head position and play a key role in stabilising motion to protect neural structures. They are densely populated with mechanoreceptors and function in conjunction with deep cervical musculature to regulate posture and balance throughout the spinal column, extending influence to the pelvis. (9)

The upper cervical spine, particularly the C2 facet joints and surrounding musculature, contains a high concentration of mechanoreceptors such as Pacinian corpuscles and Golgi tendon organs. These receptors provide continuous sensory input to the central nervous system regarding head position, enabling coordinated spinal balance and movement. Dysfunction within these structures, resulting from injury, degeneration, or subluxation, may impair cervical repositioning sense and force compensatory adjustments within the lower spine and pelvis. (17)

In evaluating cranial-pelvic balance, it is therefore necessary to consider all anatomical and myofascial structures that influence this relationship. For this reason, SOT practitioners often palpate and evaluate the longitudinal occipital myofascial fibres along the occipital bone. (18)

Neuro-anatomically, the greater occipital nerve (GON) arises from the C2 spinal nerve and travels between the obliquus capitis inferior and semispinalis capitis muscles. Although primarily sensory, supplying the posterior scalp, it also influences suboccipital musculature. Irritation or entrapment of this nerve, commonly occurring near the C2 level, may result in occipital neuralgia, characterised by scalp pain or hypersensitivity. (19)

Additionally, the lesser occipital nerve, which originates from the cervical plexus (primarily C2), supplies sensation to the lateral occipital region extending toward the posterior auricular area. (19)

> Taken together, these anatomical and neurological relationships suggest another measurable parameter that may be incorporated into a comprehensive spine-to-pelvis evaluation. Within a full-spine clinical model, such as that advocated in Sacro Occipital Technique, postural balance and autonomic nervous system regulation are viewed as interdependent components of a unified biomechanical system.

Radiographic Measurement of C2 Slope and Pelvic Tilt

The measurement of C2 slope and pelvic tilt can be performed using standard radiographic analysis.

1. Determining the C2 Angle (Occiput–C2 Angle) Using a lateral cervical spine radiograph:
    - Draw a line along the inferior endplate of C2 (Line C in Figure 2).
    - Draw a second line along McGregor's Line, extending from the posterior hard palate to the base of the occiput (Line A in Figure 2).
    - The angle formed between these two lines represents the occiput–C2 angle.

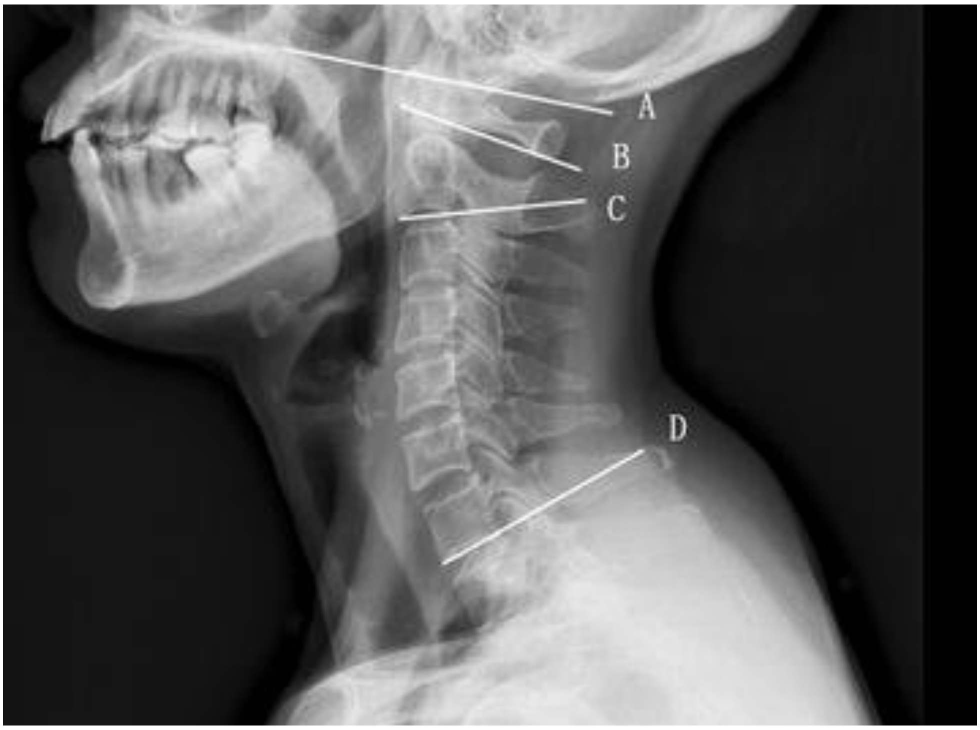

Figure 2

2. Determining the Pelvic Tilt
    - Draw Line 1 (Vertical Axis): a vertical line passing through the midpoint between the centres of the femoral heads.
    - Draw Line 2 (Pelvic Radius): a line extending from the centre of the femoral heads to the midpoint of the sacral endplate (the superior surface of the sacrum).
    - The acute angle between these two lines represents the pelvic tilt (PT) (Figure 3).

Figure 3

The full relationship between these measurements is illustrated in Figure 1.

The myodural bridge (MDB)

Beyond the relationship between the C2 angle and pelvic tilt, the angulation of C2 exerts additional and potentially profound effects on global spinal balance. This relationship warrants careful consideration by chiropractors in general and by practitioners of Sacro Occipital Technique (SOT) in particular. The C2 angle, specifically the O/C2 or craniocervical angle, has a significant influence on the function of the myodural bridge (MDB). Misalignment or altered angulation at C2 may generate abnormal mechanical stress on the cervical dura through the rectus capitis posterior minor and major (RCPm, RCPma) and the obliquus capitis inferior (OCI) muscles. (20, 21, 22) Increased tension transmitted through these structures has been associated with chronic cervicocephalic headache syndromes, altered cerebrospinal fluid (CSF) dynamics, and increased intracranial pressure. (23)

The primary function of the MDB is believed to be the prevention of dural infolding or inward collapse during cervical extension. By maintaining dural patency, the MDB facilitates the normal circulation of CSF. Compromise of the C2 angle may impair the ability of the MDB to retract the dura appropriately, potentially resulting in abnormal contact between the dura and adjacent neural structures, including the brainstem and spinal cord. Additionally, the MDB appears to contribute to a dynamic mechanism that assists in CSF circulation during physiological head movements such as nodding. Substantial deviation in C2 alignment may disrupt this mechanism, thereby altering intracranial pressure regulation and CSF circulation. (24)

Anatomically, the myodural bridge constitutes a direct connective interface between the dura mater and the suboccipital musculature, specifically the rectus capitis posterior major and minor (RCPma, RCPm) and the obliquus capitis inferior (OCI). These muscles originate from the posterior elements of the axis, particularly the C2 spinous process, and transmit force through fascial continuities to the cervical dura. Abnormal C2 angulation or positional deviation, sometimes described clinically as 'wandering C2', may result in excessive mechanical traction on the dura mater via the MDB. (24)

The MDB, linking the suboccipital muscular fascia to the dura mater, contributes to both passive and active stabilisation of the spinal cord. The structural relationships between the MDB, the dura, and the spinal column are complex and suggest potential biomechanical and neurophysiological implications not only within the cranial vault but throughout the entire spinal axis and into the pelvic region.

The dura mater demonstrates firm attachments to the posterior aspects of the C2 and C3 vertebral bodies, providing structural stability to the upper spinal cord. Additional stabilisation of the spinal meninges is provided by the ligamentum nuchae, ligamenta flava, the ligaments of Hoffman, and the ligaments of Trolard, before the dural system ultimately anchors to the coccyx through the continuation of the pia mater known as the filum terminale. (25, 26, 27, 28, 29) The filum terminale traverses the sacral hiatus and contributes to anchoring the dural sac to the periosteum of the coccyx, together with the ligament of Trolard (Figure 4). This arrangement establishes a continuous anatomical and mechanical linkage between the upper cervical spine and the complex.

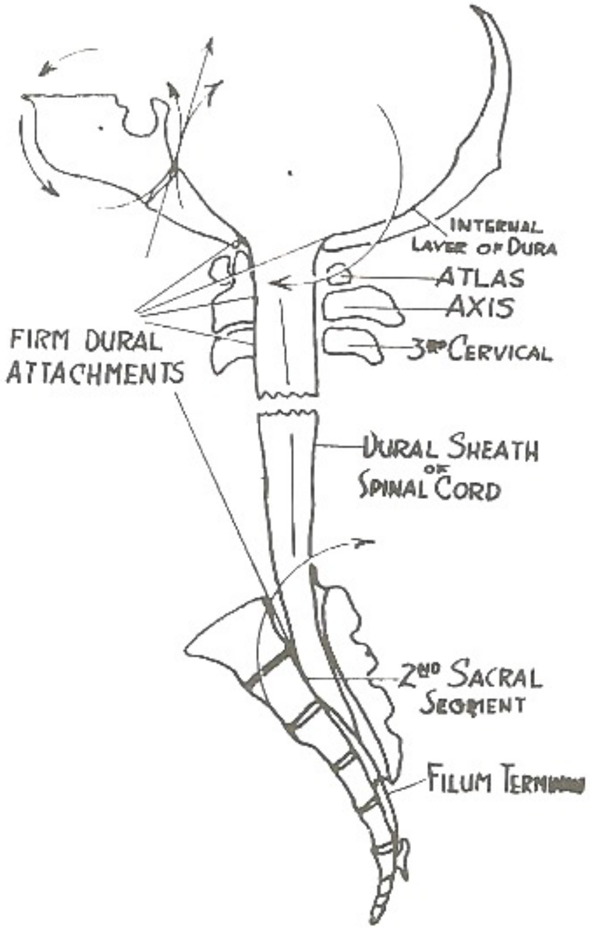

Figure 4: From Magoun and Sutherland.

Aberrant C2 angulation may therefore influence CSF circulation and alter the mechanical integrity of the dural anchoring system, both of which represent critical focal considerations in SOT management. When C2 deviates from its normal lordotic orientation, as may occur with reduced C2–C7 lordosis or increased C2 slope and associated instability, abnormal mechanical forces may be transmitted through the MDB. Such forces may result in overstretching or functional compromise of the bridge, potentially allowing posterior displacement or compression of the dura against the brainstem. Although the C2–C7 angle is generally reported to range from approximately 13.9° to 23°, clinically meaningful changes in dural tension may occur as this relationship approaches thresholds of structural instability or in the presence of kyphotic deformity. (30)

Detailed examination of the myodural bridge–meningeal complex (Figure 5) illustrates that the posterior atlanto-occipital membrane (1) extends from the occipital bone and blends with the dura mater at the craniovertebral junction. The superior myodural bridge (2) merges with the superior vertebrodural ligament (3) of the atlas and integrates with the posterior atlanto-occipital membrane (PAOM). The PAOM represents a critical ligamentous structure at the craniovertebral junction, connecting the occiput to the atlas and contributing to cervical stability.

Functionally, it acts as a continuation of the ligamentum flavum and plays an important role in limiting excessive cervical flexion. The PAOM is located at the level of the atlanto-occipital interspace. (31, 32)

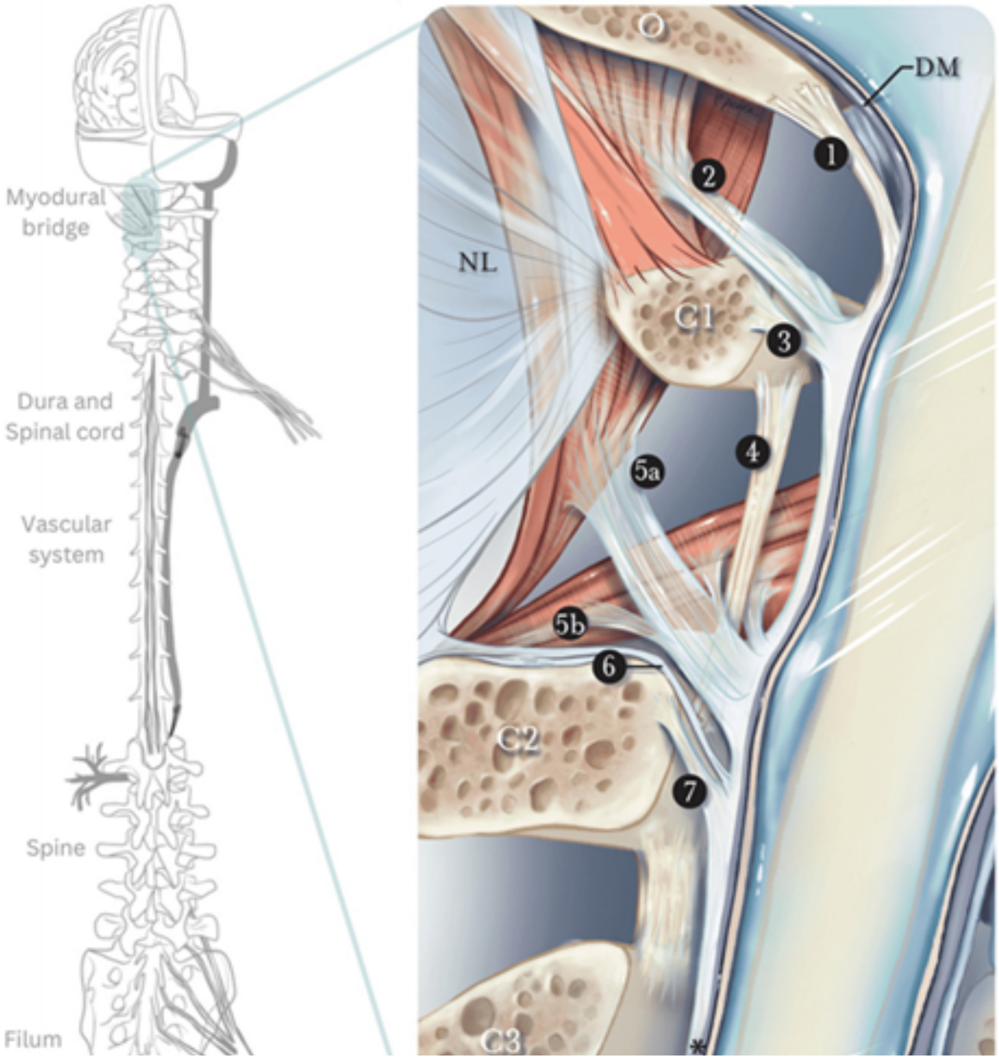

Figure 5: Neuraxial biomechanics, fluid dynamics, and myodural regulation: rethinking management of hypermobility and CNS disorders- Frost, N.

Discussion

The evolution of scientific understanding often leads to the reevaluation or abandonment of earlier theoretical frameworks. Nevertheless, historical precedent demonstrates that foundational concepts developed through careful clinical observation frequently retain considerable validity. For example, ancient Greek astronomers accurately mapped planetary motion long before the invention of telescopic instrumentation, and Leonardo da Vinci conceptualised mechanical innovations centuries before technological advances made their realisation possible.

In a similar manner, early Chiropractic pioneers relied primarily on meticulous clinical observation and radiographic analysis to formulate biomechanical models of spinal function. Consequently, contemporary scientific validation should be viewed not as a replacement for earlier insights but as an opportunity to refine and contextualise them within a modern evidence-based framework.

These considerations raise several clinically relevant questions. Should clinicians routinely evaluate and, when indicated, address C2 slope or alignment prior to initiating pelvic correction? If pelvic correction is performed first, what biomechanical events occur when the patient returns to an upright posture and postural righting reflexes are immediately activated? Does the correction persist, or does the neuromusculoskeletal system rapidly reestablish preexisting compensatory patterns? Furthermore, should assessment of the C2 angle be incorporated into clinical strategies intended to influence CSF dynamics and dural tension patterns?

Conclusion

Given that Sacro Occipital Technique has been practiced for several decades with consistently favourable clinical outcomes, it is plausible that the SOT category system already accommodates the functional relationship between C2 alignment and pelvic mechanics in an integrated and adaptive manner. (33, 34) This perspective may also help explain why cervical spine adjustment is traditionally emphasised within SOT protocols following category diagnosis and treatment, and prior to the patient assuming a weight-bearing posture.

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