Computed Tomography of Paediatric Atlanto-axial Rotatory Subluxation: The Multiple Image Addition Method

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ABSTRACT

Paediatric atlanto-axial rotatory subluxation is an uncommon condition which may be catastrophic, even after minor trauma, if it is not recognised promptly. Many imaging methods may be used to diagnose the condition, but there is still no consensus as to which is the best method for definitive diagnosis and for the assessment of treatment outcomes. Plain cervical radiography and computed tomography of the cervical spine with three-dimensional reconstruction, are currently the most accepted methods.

Multiple contiguous axial computed tomographic images of the cervical spine, compressed into a single image by multiple image addition have been utilised by the authors in radiological assessment of paediatric atlanto-axial rotatory subluxation. The authors report this technique to be an easy and accurate method for both the diagnosis and assessment of treatment. This reconstruction method is less time-consuming than three-dimensional reconstruction. In addition, the summated axial images follow the diagrammatic classification described by Fielding and Hawkins, facilitating interpretation and accurate assessment during follow-up.

Key Words: Atlanto-axial rotatory subluxation, Axial cervical computed tomography, Multiple image addition, Summated axial image

INTRODUCTION

Atlanto-axial rotatory subluxation has many synonyms. Commonly, it is termed atlanto-axial fixation because clinically the abnormality is that of an irreducible torticollis (Figures 1 and 2). Dynamic computed tomography (CT) with head turning, demonstrates the C1 and C2 facet subluxation. Three-dimensional reconstructed images may give additional information in preoperative planning, but requires tedious post-imaging processing. The technique favoured by the authors is to select several contiguous images of the C1 to C2 facet region in unenhanced axial CT views of the cervical spine and compress these into a single image by multiple image addition to demonstrate the subluxation. The summated axial image is easy to produce. It can be quantified, which allows for accurate assessment of the degree of subluxation, and is also useful for assessing treatment outcomes.

TECHNIQUE

In this report, the application of the technique in the management of 2 paediatric patients with atlanto-axial rotatory subluxation, is described. The first patient was an 8-year old boy (Figures 1 and 3) and the second, a 9-year-old girl (Figures 2, 4 and 5). Both patients had no identifiable cause for their torticollis and were neurologically stable at the time of presentation. The second patient was treated with halo traction for one month with follow-up dynamic cervical CT (Figure 5). Multiple 3 mm collimation axial unenhanced CT scans of the cervical spine were performed. Dynamic CT with the patient’s head in the neutral position and with rotation to the left and right were completed, and separate summated axial images were reconstructed. Selected contiguous sections of the C1 to C2 facet region were added together and compressed into a single image using the multiple image addition method (CT Hispeed Advantage, General Electric, Milwaukee, USA).

DISCUSSION

The aetiology of atlanto-axial rotatory subluxation can be congenital or acquired. The commonest acquired
cause is trauma, which is usually minimal. Other causes include upper respiratory tract infections, such as a retropharyngeal abscess, seronegative spondyloarthropathy, Marfan’s syndrome, and surgery, such as pharyngoplasty. Atlanto-axial rotatory subluxation can also occur secondary to odontoid hypoplasia.

Early diagnosis of atlanto-axial rotatory subluxation is crucial to patient management, because the major factor predicting the failure of conservative management is the duration of subluxation before initial reduction. Despite many reports in the literature, there is still no consensus about which imaging studies should be used for definitive diagnosis and the assessment of treatment progress. Traditionally, diagnosis of the disease was made by plain cervical radiography, showing tilting of the head to one side in the frontal view, classically described as ‘robin listening to a worm’ (Figure 1a). The lateral view of the cervical spine shows failure of superimposition of the two elements of the posterior arch of C1. This sign, however, is best seen in true lateral projection, which is difficult to obtain in patients with torticollis, thereby decreasing the accuracy of this sign. The open-mouth, odontoid peg view demonstrates asymmetrical width of the odontolateral mass interval (Figure 1b). Although plain cervical radiography may suggest the diagnosis of atlanto-axial rotatory subluxation, it may be difficult to produce radiographic images of consistent quality, especially for follow-up assessment after treatment.

Dynamic unenhanced axial cervical CT studies, turning the patient’s head to either side, and usually with multiple 1 or 3 mm collimation and postimaging three-dimensional reconstruction, are currently the best method for the diagnosis of atlanto-axial rotatory subluxation in patients with torticollis. With the multiple image addition method, summated axial images make interpretation easier and allow classification of the subluxation according to the different types described by Fielding and Hawkins. These 4 types are:

- type 1: rotatory subluxation without anterior displacement of the atlas (atlanto-odontal interval 3 mm or less)
- type 2: rotatory subluxation with anterior displacement of the atlas of 3 to 5 mm
- type 3: rotatory subluxation with anterior displacement of more than 5 mm
- type 4: rotatory subluxation with posterior displacement.

In the authors’ experience, the summated axial images simulate the original diagrammatic classification described by Fielding and Hawkins. This classification...
is still currently used by clinicians because it provides some guidance as to prognosis and treatment.

Type 1 is the most benign and common condition. The transverse ligament is intact, and subluxation is within the range of atlanto-axial rotation, with the odontoid acting as the pivot. The condition of the first patient described herein, would be classified as type 1 subluxation (Figure 3). The type 2 condition is associated with a deficient transverse ligament, and unilateral anterior displacement of one lateral mass of the atlas, while the opposite intact joint acts as the pivot. Type 3 and 4 conditions are rare, but have catastrophic potential. In type 3 subluxation, as illustrated in the second patient described (Figure 4), there is a deficiency of both the transverse and secondary ligaments. Both lateral masses of the atlas are displaced anteriorly. Type 4 subluxation occurs when a deficient dens allows posterior shift of one or both lateral masses of the atlas, with one shifting more than the other, so that the atlas is rotated on the axis. Type 3 and type 4 subluxation cause narrowing of the spinal canal, with potential spinal cord compression. It is therefore important to recognise types 3 and 4 subluxation early, to initiate prompt and proper treatment.

In addition to measurement of the atlanto-odontal interval, the diagnosis of atlanto-axial rotatory subluxation also depends on the movement or relationship between the atlas and axis. Both sets of summated axial images with the patient’s head turning to right and left will show rotatory subluxation if the atlas and axis remain fixed or are not moving in the same direction when the head is rotated. The dynamic relationship of the atlas and axis demonstrated by the summated axial images on head rotation achieves the same purpose as observing atlanto-axial movement during turning of the head to both sides on lateral fluoroscopy screening. The summated axial images clearly show how the C1 and C2 facets offset each other as the head rotates to either side. This assists the diagnosis and classification.
Computed Tomography of Paediatric Atlanto-axial Rotatory Subluxation

of atlanto-axial rotatory subluxation to a greater extent than conventional axial CT images alone. In addition, pre- and post-treatment CT cervical spine scans using summated axial images, are reproducible. This allows comparison and accurate assessment of treatment progress, and the need for further management, such as spinal fusion if conservative management fails to correct the subluxation. This is well illustrated in the second patient, in whom the summated axial CT images clearly demonstrated substantial but incomplete reduction of the subluxation, with subsequent spinal fusion required. The technique of preparing summated axial images to evaluate paediatric atlanto-axial subluxation, as described in this report, is extremely useful according to the authors’ experience. It has the potential for more widespread application in the diagnosis and management of atlanto-axial subluxation.

Figure 5. Marked improvement in the degree of subluxation can be seen in post-halo traction summated axial CT images. (a) Right rotation; (b) left rotation.

REFERENCES