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Inter- and Intra-observer Variability of a Cervical OPLL Classification Using Reconstructed CT Images

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Background: The lateral radiograph-based system described by Tsuyama is used widely to classify ossification of the posterior longitudinal ligament (OPLL) of the cervical spine. However, OPLL is a complex 3-dimensional (3-D) lesion, not a simple and uniplanar one, which is often difficult to identify on a lateral radiograph. Furthermore, its reliability among spine surgeons has not been investigated. Given the popularity of a reconstructed computed tomography (CT), this study examined the inter- and intra-observer reliability of lateral radiograph-based OPLL classification using that modality.

Methods: Five spine surgeons independently reviewed the lateral radiograph, axial CT, 2-D (sagittal) and 3-D reconstructed CT images of 108 OPLL patients on 2 separate occasions. Based on these images, the reviewers classified each OPLL case according to the Tsuyama's system. The kappa values were used to assess the statistical reliability.

Results: The inter- and intra-observer kappa values were only 0.51 and 0.67 for the lateral radiograph, even in combination with the axial CT images, 0.70 and 0.85 for 2-D CT images, and 0.76 and 0.86 for 3-D CT images, respectively. These kappa values showed a good-to-excellent range for the 2-D and 3-D reconstructed CT images while those of the lateral radiograph indicated a fair range. According to the OPLL types, the inter- and intra-observer reliability was low in the continuous type and high in the circumscribed type on the lateral radiograph. However, the low reliability of the continuous type on lateral radiograph was overcome somewhat using 2-D and 3-D reconstructed CT images.

Conclusions: The inter- and intra-observer kappa values were only 0.51 and 0.67 for the lateral radiograph, even in combination with the axial CT images, 0.70 and 0.85 for 2-D CT images, and 0.76 and 0.86 for 3-D CT images, respectively. These kappa values showed a good-to-excellent range for the 2-D and 3-D reconstructed CT images while those of the lateral radiograph indicated a fair range. According to the OPLL types, the inter- and intra-observer reliability was low in the continuous type and high in the circumscribed type on the lateral radiograph. However, the low reliability of the continuous type on lateral radiograph was overcome somewhat using 2-D and 3-D reconstructed CT images.

Keywords: *Ossification of the posterior longitudinal ligament, Classification, Reliability, Computed tomography*

Ossification of the posterior longitudinal ligament (OPLL) of the cervical spine is one of the most important causes of cervical myelopathy.[1-4] The system described by Tsuyama (Investigation Committee on OPLL of the Japanese Ministry of Public Health and Welfare) is the method most widely used for classifying cervical OPLL.[5] Based only

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on the lateral radiograph and/or tomogram, cervical OPLL can be classified roughly into 4 types: continuous, segmental, mixed or circumscribed (localized or others). Although it is used widely, its reliability and reproducibility among spine surgeons are unknown. In addition, there are no reports on the the inter- and intra-observer reliability of Tsuyama's lateral radiograph-based classification of cervical OPLL. With the advent of a computed tomography (CT) reconstruction in treating cervical OPLL, it is believed that it is important to determine the inter- and intra-observer reliability of Tsuyama's lateral radiograph-based classification of a cervical OPLL using that modality.

METHODS

Between 2002 and 2007, 2-dimensional (2-D) (sagittal) and 3-D CT reconstructions were performed in 108 patients exhibiting cervical OPLL on a plain lateral radiograph, axial CT and MRI. Eighty-two patients were male and 26 patients were female with a mean age of 53.7 years (range, 28 to 77 years). Of them, 48 patients underwent posterior, anterior, or combined surgery for myelopathy due to OPLL. However, 60 patients were carefully observed without surgery because they had mild or no symptoms.

Five experienced cervical spine surgeons independently reviewed the lateral radiographs, axial CT images, and 2-D and 3-D reconstructed CT images of the 108 OPLL patients on 2 separate occasions. All the radiologic images were reviewed on a single day and then re-reviewed two weeks later in a different sequence. Based on the images, the reviewers classified each OPLL case into four types according to the OPLL classification reported by Tsuyama.[5] The kappa values were used to examine the inter- and intra-observer reliability. According to Svanholm et al.,[6] a kappa value > 0.75 represents excellent reliability; 0.5 to 0.75, fair-to-good reliability; and < 0.5, poor reliability.

RESULTS

The mean inter- and intra-observer reliability of the OPLL classification was only 64% and 77% for the lateral radiographs, respectively, even in combination with the axial CT images. The mean kappa values were 0.51 and 0.67, respectively, which indicates fair reliability. For the 2-D reconstructed CT images, the mean inter- and intra-observer reliability were 81% and 92% with mean kappa values of 0.71 and 0.85, respectively, which indicates good and excellent reliability. For the 3-D reconstructed CT images, the mean inter- and intra-observer reliabilities were 85% and 93% with mean kappa values of 0.76 and 0.86, respectively, which indicates excellent reliability (Table 1).

The data was classified into four OPLL types. The inter-observer reliability of the OPLL classification was very low (17%) in the continuous type and high (88%) in the circumscribed type using the lateral radiograph in combination with the axial CT images. However, the very

Table 1. Inter- and Intra-observer Reliabilities of Cervical OPLL Classification

	Inter-observer reliability (kappa value*)	Intra-observer reliability (kappa value*)
Lateral radiograph + axial CT	64% (0.51)	77% (0.67)
2-dimensional CT	81% (0.71)	92% (0.85)
3-dimensional CT	85% (0.76)	93% (0.86)

OPLL: Ossification of the posterior longitudinal ligament.
*Kappa value of more than 0.75 indicates excellent reliability; a value of 0.50 to 0.75, fair-to-good; and a value of less than 0.5, poor reliability.[6]

Table 2. Inter-observer Reliability of Cervical OPLL Classification

OPLL type	Lateral radiograph + axial CT	2-dimensional CT	3-dimensional CT
Continuous	17%	62%	73%
Segmental	77%	87%	89%
Mixed	74%	83%	86%
Circumscribed	88%	92%	92%

OPLL: Ossification of the posterior longitudinal ligament.

Table 3. Intra-observer Reliability of Cervical OPLL Classification

OPLL type	Lateral radiograph + axial CT	2-dimensional CT	3-dimensional CT
Continuous	50%	79%	84%
Segmental	85%	96%	97%
Mixed	82%	94%	94%
Circumscribed	91%	99%	97%

OPLL: Ossification of the posterior longitudinal ligament.

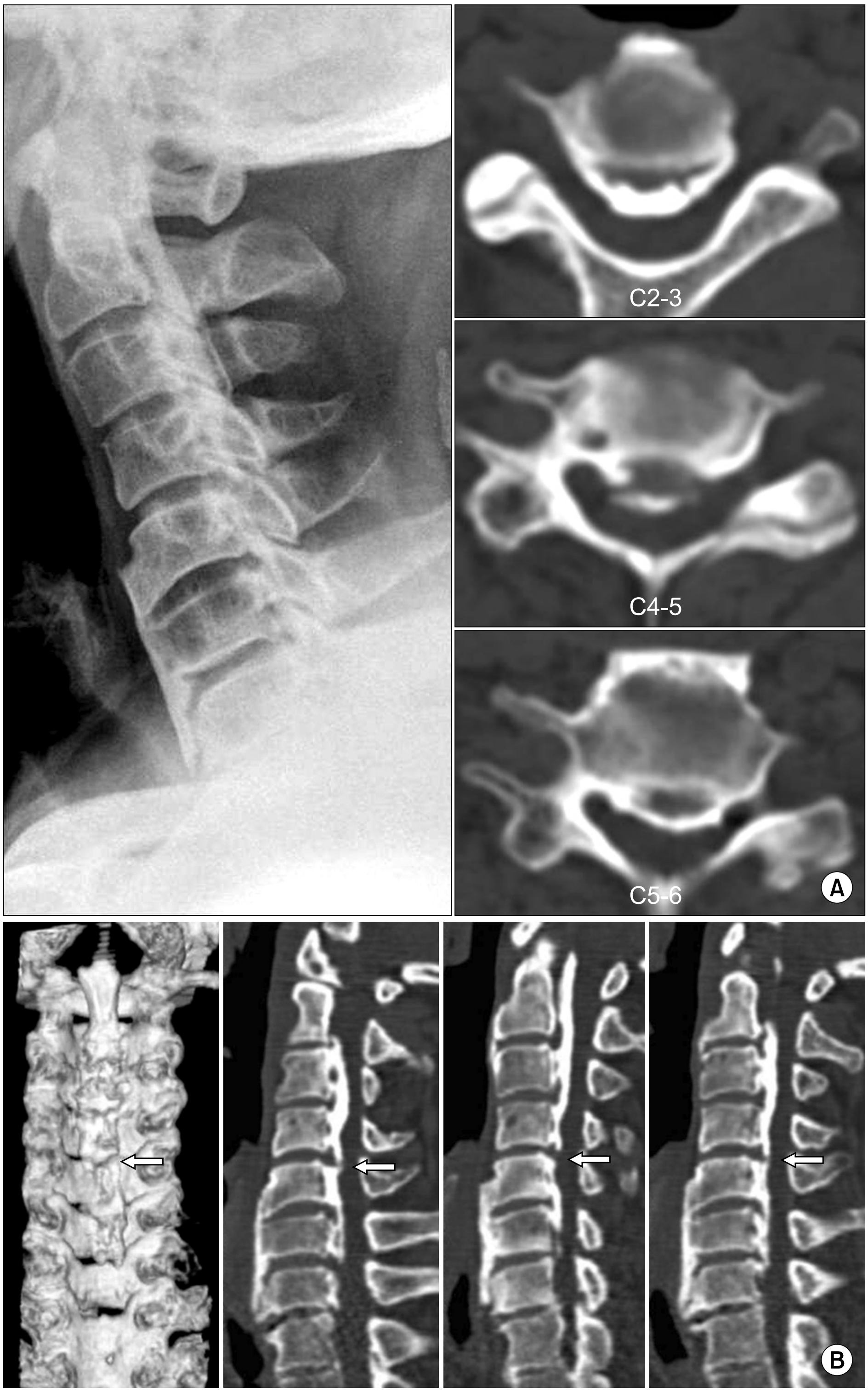

Fig. 1. Sixty-one-yr-old male patient presented with the typical clinical symptoms of cervical myelopathy due to ossification of the posterior longitudinal ligament (OPLL). Most reviewers classified this case into the continuous type OPLL extending C1 to C7 using the lateral radiograph in combination with the axial CT images (A). However, the 2-dimensional (2-D) and 3-D CT reconstructed images showed an interrupted OPLL at the C4-C5 disc level (arrow) (B). Most of the reviewers re-classified this case into the mixed type OPLL extending C1 to C7 using the reconstructed CT images.

low inter-observer reliability of the lateral radiograph in combination with the axial CT images for the continuous type was overcome using the 2-D and 3-D reconstructed CT images (62% and 73%, respectively) (Table 2). The intra-observer reliability of the OPLL classification was also low (50%) in the continuous type and high (91%) in the circumscribed type using the lateral radiograph in combination with the axial CT images. The low intra-observer reliability of the lateral radiograph in combination with the axial CT images for the continuous type was also overcome using the 2-D and 3-D reconstructed CT images (79% and 84%, respectively) (Table 3).

DISCUSSION

Classification systems are used to assess a clinical entity, enable a surgeon to recommend a particular treatment, and allow a comparison of different treatment modalities.[7] For these purposes, classification systems must have high inter- and intra-observer reliability. The classification system described by Tsuyama[5] is based only on a lateral radiograph and/or tomogram. Although it is used widely, its reliability and reproducibility among spine surgeons has not been determined. In addition, with the advent of CT reconstructions, it has been found that cervical OPLL is a 3-D complex lesion, not a simple and uni-plane. However, plain lateral radiographs cannot provide 3-D morphological structures of cervical OPLL accurately compared to reconstructed CT images. An accurate classification of the OPLL type is very important for determining the appropriate surgical approach, extent and need for additional fusion.[8-11] Therefore, this study examined the inter- and intra-observer reliability of Tsuyama's lateral radiograph-based classification of the cervical spine using reconstructed CT.

This study demonstrated that Tsuyama's lateral radiograph-based classification of cervical OPLL did not have sufficient inter- and intra-observer reliability among spine surgeons to portray the OPLL type accurately. The mean inter- and intra-observer kappa values of the lateral radiograph, even in combination with axial CT images, only indicated a fair range. However, in our cases, the 2-D and 3-D reconstructed CT images demonstrated the anatomy of the 3-D complex OPLL lesions quite well. The mean inter- and intra-observer kappa values of the 2-D and 3-D reconstructed CT images indicated excellent-to-good ranges. There were no significant differences between the 2-D and 3-D CT reconstruction, suggesting that either modality can be used reliably.

According to the OPLL types, the inter- and intra-observer reliability in the lateral radiographs in combination with axial CT images was low in the continuous type and high in the circumscribed type. The greatest difficulty encountered by the reviewers was distinguishing the continuous type from the mixed type. However, this difficulty of the lateral radiographs in combination with the axial CT images was overcome somewhat using the 2-D and 3-D reconstructed CT images. In particular, as shown in Fig. 1, most of the continuous types classified by the lateral radiograph in combination with the axial CT images were changed into the mixed type using the 2-D and 3-D reconstructed CT images. The 3-D complex ossified structures of cervical OPLL were well described with the 2-D and 3-D reconstructed CT images. Therefore, it is important to classify cervical OPLL using reconstructed CT images. However, there are no reports classifying the OPLL type using reconstructed CT images. Therefore, this is the first study to determine the cervical OPLL type by 2-D and 3-D CT reconstructions. In conclusion, these results suggest that a lateral radiograph-based classification of cervical OPLL does not have sufficient inter- and intra-observer reliability to portray the OPLL type accurately. Therefore, 2-D and/or 3-D morphologic analysis of OPLL is recommended to determine the appropriate surgical approach, extent and need for additional fusion.

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