THREE-DIMENSIONAL DEFORMITY ANALYSIS OF THE FOREARM BONES IN CONGENITAL PROXIMAL RADIOULNAR SYNOSTOSIS

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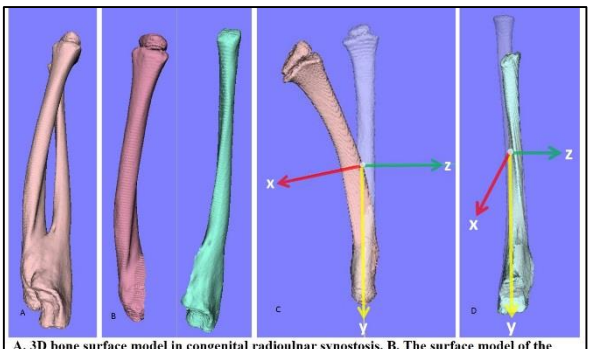
INTRODUCTION

Congenital proximal radioulnar synostosis (PRUS) is a rare congenital anomaly where the radius and ulna are fused at the proximal portion which can cause the rotation of the forearm to be restricted (Fig.1). Bilateral pronation ankylosis over sixty degrees can restrict the patient's daily activities. According to the position of the radius head in x-ray, PRUS is classified into three types, posterior dislocation type, anterior dislocation type and non-dislocation type. We performed Kanaya's mobilization procedure using a free vascularized fascio-fat graft and correction osteotomy of the radius (Kanaya 1998). Most patients gained satisfactory range of motion (ROM) after surgery. However, unsatisfactory forearm rotation can be seen in some cases. It considered that sever bone bowing of radius in the post-dislocation type might be the cause of unsatisfactory result.

In CAOS international 2014, we reported the three-dimensional (3D) analysis of deformity of the radius and ulna of PRUS. In this study, especially, flexion deformity of radius and pronation deformity of ulna were revealed, and the significantly correlation between those deformities and the pronation ankylosis of the forearm was seen. However, there was no investigation of the relationship between the dislocation type and 3D deformity. The purpose of this study was to compare the deformity among the three dislocation types of PRUS.

PATIENTS AND METHODS

A total of 38 radii and ulnae in 25 patients (17 boys, 8 girls; mean age 6 year old) were evaluated. There were 14 anterior dislocation types (ant-dislocation group), 16 posterior dislocation types (post-dislocation group), 8 no dislocation types (non-dislocation group). 3D bone surface models were created from the 3D-CT data by software.



A. 3D bone surface model in congenital radioulnar synostosis. B. The surface model of the fused forearm with synostosis was separated to the radius and ulna using 3D analysis software. C. Coordinate system of the left radius used to assess deformity in 3 directions2-3). The rotational angle around the x, y, and z axes indicates valgus (+) or varus (-), pronation (+) or supination (-), and extension (+) or flexion (-), respectively. D. Coordinate system of the left ulna. The rotational angle around the x, y, and z axes indicates extension (+) or flexion (-), pronation (+) or supination (-), and valgus (+) or varus (-), respectively.

The normal bone surface models corresponding to each age were created by a similar method. The 3D deformity was analysed in the following way (Fig.1). First, the

proximal part of the affected bone was semiautomatically superimposed on the normal bone. Next, the distal part was superimposed. Then, the amount of 3D deformity of the distal part was quantified using Euler angles method (Wu 2005, Kim 2012). The degree of deformity among 3 dislocation types was compared (Miyake 2013).

RESULTS

The deformity of each dislocation group were revealed (Table 1). In the post-dislocation group, the flexion deformity of radius and pronation deformity of ulna was seen the most severe among 3 groups ($p<0.01$). In the non-dislocation group, the pronation deformity of ulna was seen significantly more severe than ant-dislocation group ($p<0.01$). In the ant-dislocation group, the extension deformity of ulna was seen the most severe among 3 groups ($p<0.01$).

Radius

Average degrees of deformity	Post-dislocation group	Non-dislocation group	Ant-dislocation group
Flexion deformity	13.3°	0.6°	-2.2°
Ulnar deviation	9.4°	6.4°	5.1°

Ulna

Average degrees of deformity	Post-dislocation group	Non-dislocation group	Ant-dislocation group
Flexion deformity	0.2°	0.8°	-7.1°
Radial deviation	5.9°	2.2°	0.8°
Pronation	47.2°	36.3°	8.8°

DISCUSSION

This study showed that the degree of 3D deformity was different among the three groups. Especially the severe 3D deformity was found in post-dislocation type.

Although it was considered that the non-dislocation type of PRUS was mild deformity in the three types, 3D deformity analysis revealed that there was over 35 degrees in pronation deformity of ulna. This result suggests that the supination osteotomy of the ulna might be required for not only the posterior dislocation type but also no dislocation type of PRUS.

Dynamic data including neutral, maximum pronation and rotation of forearms before and after surgery should be investigated for the most important factor in decision making.

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DISCLOSURES

Author and co-authors have no COI.

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INTRODUCTION

Congenital proximal radioulnar synostosis (PRUS) is a rare congenital anomaly where the radius and ulna are fused at the proximal portion. PRUS is classified into three types according to radius head position in x-ray, posterior dislocation type, anterior dislocation type and non-dislocation type. However, little information has been available on the 3-dimensional (3D) deformity patterns, including axial rotation deformity. The purpose of this study was to compare the deformities among the three dislocation types of PRUS.

PATIENTS AND METHODS

A total of 38 radii and ulnae in 25 patients (mean age: 6 y-o.) were evaluated. 3D computer models of bilateral radius and ulna were created from computed tomography data. We evaluated deformity by superimposing the mirror-image bone model of the contralateral normal bone onto a model of the affected bone.

RESULTS

In the posterior dislocation group (n=16), the flexion deformity of radius and pronation deformity of ulna were seen the most severe among 3 groups ($p<0.01$). In the non-dislocation group (n=8), the pronation deformity of ulna was seen significantly more severe than ant-dislocation group ($p<0.01$). In the anterior dislocation group (n=14), the extension deformity of ulna was seen the most severe among 3 groups ($p<0.01$).

DISCUSSION

It was considered that non-dislocation type of PRUS was mild deformity in the three types, however our result showed that severe pronation deformity of ulna was found. This suggests that an additional supination osteotomy of the ulna might be required for not only the posterior dislocation type but also non-dislocation type of PRUS.