

Quantitative Analysis of the Head Tilt Using 3-D Temporal Scan in Children with Torticollis

Nae Yoon Kang¹, Jung Hyun Yang¹, Kyeong Jae Lee¹, Won Sik Dho¹, Ra Yu Yun¹, Hayoung Jung²,
Xin Cui², Sungchul Huh¹, Wonsup Lee³, Heecheon You², Soo-Yeon Kim^{1*}

Department of Rehabilitation Medicine, Pusan National University Yangsan Hospital¹

Department of Industrial & Management of Engineering, Pohang University of Science and Technology²

School of Global Entrepreneurship and Information Communication Technology, Handong Global University³

Introduction

Torticollis is a common pediatric musculoskeletal condition, which is classified by plane or axis of the neck and head deviations. However, measuring the torticollis in a two-dimensional manner in children has limitation due to their poor cooperation. With development of three-dimensional (3D) scanning technology, it became possible to promptly capture the head and neck deviation quantitatively and this study aimed to objectively demonstrate head tilt through clinical measurements and 3D scanning in young children.

Method

We performed cross-sectional study using the data of 52 patients diagnosed with torticollis and 52 adults without torticollis to set the reference value. For clinical measurement, we used goniometer method to measure angle between imaginary line of the philtrum and a line to both clavicles by two physiatrists, still photography method measuring the angle formed by the line connecting two eyes and the line connecting the acromion and 3D scan method. On 3D scan method, we used landmarks attached to subnasal, sellion, promental, both infraorbitale, ectocanthus, tragion and acromion of the participant for 3D scanning (Fig. 1). Intra-class correlation (ICC) coefficient was used to compare three method measurements' reliability and Pearson's correlation analysis was conducted between goniometer measurements and 3D angle using a 3D scanner. The Mann-Whitney U test was performed for comparing patient groups to control groups and receiver operating characteristic (ROC) curve was used to determine the cut-off value for diagnosing torticollis.

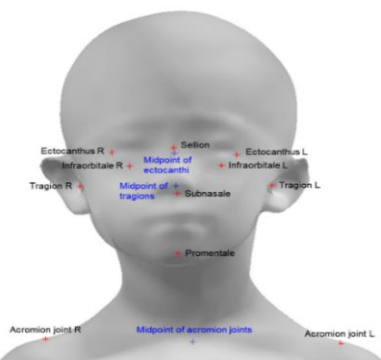


Figure 1. Landmarks for head angle analysis in 3D angle method

Result

The average angle differences between control group and torticollis group showed significant differences by using any methods (Table 1). Reliabilities of torticollis between measurements were all statistically significant using ICC method (Table 2). Correlation coefficient between the goniometer method and 3D angle was 0.720 ($p < 0.001$), and between still photography method and 3D angle was 0.727 ($p < 0.001$). For the diagnosis of torticollis using the 3D angle, the cut-off value was 4.950, the sensitivity was 0.788 and 1-specificity was 0.212 obtained through the ROC curve. The area under curve was 0.872.

Table 1. Angles with multiple methods and differences in angles between the control and torticollis groups

	Control Group	Torticollis Group	p-value
Goniometer method by physiatrist 1	1.13 ± 1.10	6.67 ± 7.45	<0.01*
Goniometer method by physiatrist 2	1.15 ± 1.02	6.77 ± 7.24	<0.01*
still photography method	1.38 ± 1.07	6.98 ± 7.26	<0.01*
Yaw angle with 3D scanner	1.54 ± 0.91	6.08 ± 5.79	<0.01*
Roll angle with 3D scanner	2.13 ± 1.60	6.19 ± 6.33	<0.01*
Pitch angle with 3D scanner	5.78 ± 3.52	10.37 ± 6.65	<0.01*
3D angle (comprehensive angle considering yaw, roll, and pitch angles)	3.60 ± 1.55	11.07 ± 7.65	<0.01*

Values are presented as means of absolute values ± standard deviation. Asterisk means statistically significance ($p < 0.05$).

Table 2. Reliability of torticollis measurements

	ICC (3,1)	95% CI	p-value
Goniometer method of two physiatrists	0.997	0.995-0.998	<0.001*
Goniometer method by physiatrist 1 and still photography method	0.996	0.994-0.997	<0.001*
Goniometer method by physiatrist 2 and still photography method	0.997	0.996-0.998	<0.001*
Goniometer method by physiatrist 1 and roll angle with 3D scanner	0.944	0.918-0.962	<0.001*
Goniometer method by physiatrist 2 and roll angle with 3D scanner	0.949	0.925-0.965	<0.001*

ICC; Intra-Class Correlation, CI; Confidence Interval, Asterisk means statistically significance ($p < 0.05$).

Conclusion

This is the first study to obtain head tilting, rotation, vertical and combined 3D angles using a 3D scanner. Compared with that of the control group, the 3D angle value was significantly larger in the patient group and showed high correlation with other measurement methods. With further research, it is thought that torticollis can be evaluated three-dimensionally and the values can be used in clinical practice.

* Corresponding author's e-mail: drkimy@gmail.com