The Development and Clinical Application of a Device to Enhance the Accuracy of Acetabular Cup Implantation and Balance Lower Limb Length in Total Hip Arthroplasty

Xiangyu Qian[1], Yun Gao[2], Wenjing Yin[2], Zhenzhong Zhu[2], Changqing Zhang[2], Jiagen Sheng[1]
[1]Jinzhou Medical University, Liaoning, China; [2]Department of Orthopedics, Shanghai No.6 People's Hospital Affiliated to Shanghai Jiaotong University
Email: shengjiagen@126.com

INTRODUCTION:

Total hip replacement is the most effective solution for end-stage osteoarthritis of the hip and femoral neck fracture in the elderly [1]. The poor prognosis is mainly led by lower limb inequality and prosthesis dislocation [2]. Nowadays, surgeons mostly rely on visual assessment of the abduction angle, anteversion angle and patient's lower extremities equality during THA, which is greatly based on surgeons' experience. Our team has designed a device to improve the accuracy of acetabular cup implantation and to balance the lower limb length in THA based on the anatomical characteristics of the hip and has successfully applied this device in THA.

METHODS:

This study has analyzed the postoperative anteversion and abduction angles and bilateral lower extremity lengths in 78 patients with primary THA in our department. All patients underwent the THA procedure using the supine position - Hardinge approach. The patients were divided into two groups: 39 hips received THA with the aid of the device (experimental group), while the other 39 hips were without the aid of the device (control group). Postoperatively, patients in both groups received hip CT examination and direct measurement of lower limb length (the distance between ipsilateral anterior superior iliac spine and medial malleolus). The outcomes including anterversion angle, abduction angle, and bilateral lower extremity length difference were measured by two surgeons according to the double-blind principle. According to the Lewinnke Safe Zone theory, the range of abduction angel and anteversion angel were set 40°±10°and 15°±10°respectively [3]. The absolute discrepancy between the lengths of the lower limbs was set at less than 10 mm [4]. Data is analyzed using SPSS statistical software, and differences were compared using t-test and Levene's test. Categorical data is compared using the chi-square test. P-value < 0.05 is considered statistically significant.

During operation, the device is mounted on bilateral anterior superior iliac spines (A, B, C) and detachable telescopic rods are installed to measure the length of the patient's legs when placed on the first guide post (Fig A-8, F), and to indicate the acetabular anteversion and abduction angles when placed on the second guide post (Fig A-9, C, D, E). The detail of the device design has been described previously [5].

RESULTS:

There is no statistical difference in the gender, age, height, weight, and BMI of patients between experimental and control groups (all P > 0.05) (Table 2). While all hips from experimental group have reached the "abduction safe zone", 23.08% (9/39) hips from control group did not reach the "abduction safe zone" (P<0.05). 10.26% (4/39) hips from experimental group and 41.03% (16/39) hips from control group did not reach the "anteversion safe zone" (P<0.05). There are 10.26% (4/39) hips from control group did not reach "abduction safe zone" and "anteversion safe zone" simultaneously (P>0.05). 28.21% (11/39) hips from control group and 17.95% (7/39) hips from experimental group had limb length difference greater than 10mm postoperatively (P>0.05) (Table 1).

DISCUSSION:

The malposition of components and postoperative lower limb inequality impair the rehabilitation trajectory and the quality of life. Although many methods can assess the abduction angle, anteversion angle, and reduce the bilateral lower extremity inequality in THA, they are often less accurate. Our device can effectively and accurately provide anteversion and abduction angle reference during THA. Yet, larger number of subjects might be needed to evaluate the effectiveness of this device in terms of lower limb length guidance.

SIGNIFICANCE:

This device is able to homogenize and shorten the learning curve of the THA procedure by assisting surgeons to more accurately grasp the acetabular parameters.

REFERENCE:

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Table 1 Number of hips failed to reach the threshold

Hip Parameters	Control (n=39)	Experimental (n=39)	P-value
Anteversion angle safe zone	16	4	0.003
Abduction safe zone	9	0	0.002
Anteversion angle & Abduction safe zone	4	0	0.12
Lower limb length difference	11	7	0.42

Table 2 Basic characteristics and outcomes in the enrolled hips

Basic Characteristics & Outcomes	Control (n=39)	Experimental (n=39)	P-value
Age	68.85±7.13	71.44±6.59	0.10
Weight	69.64±8.01	71.89±6.59	0.18
Height	1.66±0.07	1.65±0.07	0.61
BMI	25.24±2.86	26.35±2.79	0.09
Anteversion angle	17.82±9.24	16.25±6.32	0.39
Abduction angle	40.79±8.87	41.38±3.97	0.71
Lower limb length difference	7.49±6.62	5.51±4.15	0.12