Safe zone for the superior gluteal nerve in the transgluteal approach to the dysplastic hip
Intraoperative evaluation using a nerve stimulator

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Background The superior gluteal nerve can be damaged during the transgluteal approach to the hip in total hip arthroplasty.

Methods We studied 30 patients with hip dysplasia who underwent total hip arthroplasty through the transgluteal approach. The course of the inferior branch of the superior gluteal nerve was identified using a nerve stimulator. The distance between the nerve and the tip of the greater trochanter was measured.

Results The mean distance was 37 (25–45) mm at the anterior third, 40 (30–50) mm at the middle third, and 44 (35–55) mm at the posterior third of the gluteus medius. The distance was influenced by the severity of hip dysplasia and decreased as the degree of hip dysplasia became more severe.

Interpretation A 3-cm safe zone is appropriate in most dysplastic hips. In severely dysplastic hips, however, the superior gluteal nerve occasionally coursed within 3 cm of the tip of the greater trochanter. In such hips, a nerve stimulator can be used to identify the nerve.

Patients and methods
We studied 30 Japanese patients (21 women) with hip dysplasia who underwent primary total hip arthroplasty through the transgluteal approach between August 2003 and June 2005. All patients gave informed consent. Their mean age was 68 (52–86) years. Mean height was 1.51 (1.38–1.72) m. Mean body weight was 57 (41–82) kg. The severity of hip dysplasia, defined as the distance between the teardrop line and the head-neck junction divided by the pelvic height, was measured on the preoperative...
anteroposterior radiograph of the pelvis according to Crowe et al. (1979) (Figure 1). 15 hips were in group I, 12 were in group II, and 3 were in group III (Figure 2). All procedures were performed in the lateral decubitus position. After the skin and the fascia lata were incised, both the anterior and posterior borders of the gluteus medius were exposed. 3 lines (anterior third, middle third, and posterior third) were drawn using a gentian violet surgical marker, with the width of the gluteus medius as a reference. We identified the course of the inferior branch of the SGN using an electric nerve stimulator (Neutracer; Top Corp., Tokyo, Japan). A Teflon-coated stimulation needle (Pole Needle 25G, 50 mm; Top Corp., Tokyo, Japan) was inserted into the gluteus medius at about 2–4 cm depth, just above the TT. The stimulator was set to deliver a 2-mA pulse at a frequency of 2 Hz. We moved the needle from distal to proximal, along the 3 lines, to find the point where the anterior portion of the gluteus medius contracted; and when found, the amplitude of the stimulator was turned down to 1 mA.
We moved the needle, and the point which elicited maximum contraction of the muscle was considered to be the location of the inferior branch of the SGN. The distance between the nerve as identified by the stimulator and the TT was measured using a ruler at 5-mm intervals (indirect measurement) (Figure 3). All procedures to identify the course of the nerve using the stimulator were performed by a single observer (MI) and completed within 5 min.

In 10 of the 30 patients, we exposed the inferior branch of the SGN at the anterior third of the gluteus medius to evaluate the reliability of the measurement. This direct measurement of the distance between the inferior branch of the SGN and the TT was done using a ruler. We regarded the difference in the distance between the direct and indirect measurement as the measurement error. We observed the trunk of the inferior branch of the SGN close to the point determined by indirect measurement in all 10 patients; the measurement error was within 5 mm. The mean value of the error was 2.5 (SD 1.6) mm. The results of indirect measurement were always shorter than those of direct measurement.

Statistics
We used analysis of variance followed by the Fisher protected least significant difference (PLSD), with \( p < 0.05 \) indicating statistical significance. We used multiple regression analysis to examine the relationships between continuous variables, including body height and the severity of hip dysplasia, and the distance between the inferior branch of the SGN and the TT.

Results
The mean distance between the inferior branch of the SGN and the TT was 37 (25–45) mm at the anterior third, 40 (30–50) mm at the middle third, and 44 (35–55) mm at the posterior third. The branch ran slightly obliquely downward and forward and was located at a distance of 25–55 mm above the TT. The distance between the nerve and the TT was greater than 30 mm in all but 2 severely dysplastic hips (Crowe group III) at the anterior third of the gluteus medius. The distance between the nerve and the TT at the anterior third was shorter than that at the middle third and at the posterior third (\( p = 0.02 \) and 0.003, respectively). Regarding any correlation of body height and the severity of hip dysplasia with the distance between the nerve and the TT on multiple regression analyses, the severity of hip dysplasia showed a moderate inverse correlation with this distance (Table). Body height showed a poor correlation with the distance. These findings suggest that the distance between the nerve and the TT is influenced more by the severity of hip dysplasia than by body height. The distance between the nerve and the TT decreased as the degree of hip dysplasia became more severe.

Discussion
To our knowledge, there have been no previous studies investigating the course of the SGN in the dysplastic hip. We found that the distance between the nerve and the TT varies with the severity of hip dysplasia. With a safe zone of 30 mm, we can safely perform surgery in most hips regardless of where the gluteus medius is split. However, the inferior branch of the SGN coursed within 30 mm above the TT at the anterior third of the gluteus medius in severely dysplastic hips (2 hips in group III). In these hips, we recommend splitting the posterior portion of the gluteus medius or the use of a nerve stimulator.
According to a small number of reports (Bos et al. 1994, Eksioglu et al. 2003), there is a significant correlation between body height and the distance between the SGN and the TT. It is to be expected that the SGN would course closer to the greater trochanter in patients with short stature. Most previous cadaveric studies have not reported the height of the cadavers. Although we found a poor correlation between body height and the course of the SGN, this may have been due to the small number of patients and the presence of hip dysplasia. We consider that particular care should be taken in patients with short stature.

Identification of the inferior branch of the SGN using a nerve stimulator (indirect measurement) was simple and reliable. We consider that measurement with less than 5 mm error is acceptable in clinical settings. The results of indirect measurement were always shorter than those of direct measurement. Thus, it could be safe for the nerve to split the gluteus medius according to the indirect measurement. However, we consider that identification of the nerve using a stimulator is not always necessary; surgery is safe in most dysplastic hips regardless of where the gluteus medius is split within the 30 mm safe zone. Identification of the nerve using a stimulator may only be useful in patients with severely dysplastic hips (i.e. Crowe group III and IV), since the nerve courses unexpectedly close to the greater trochanter in these patients.

**Contributions of authors**

MI conception and design, data acquisition and analysis, manuscript writing and revision. TK conception and design, manuscript revision. NY data analysis, manuscript writing and revision. YO and TT data analysis, manuscript revision.

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