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Perioperative versus postoperative measurement of Taylor Spatial Frame mounting parameters

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Objective: The aim of this study was to determine the differences, if any, between application parameters for the Taylor Spatial Frame (TSF) system obtained during surgery under fluoroscopy and after surgery from digital radiography.

Methods: This retrospective study included 17 extremities of 15 patients (8 male, 7 female; mean age: 21.9 years, range: 10 to 55 years) who underwent TSF after deformity and fracture. Application parameters measured by fluoroscopy at the end of surgery after mounting the fixator were compared with parameters obtained from anteroposterior and lateral digital radiographs taken 1 day after surgery.

Results: Fixator was applied to the femur in 8 patients, tibia in 6 and radius in 3. Mean time to removal of the frame was 3.5 (range: 3 to 7) months. Mean perioperative anteroposterior, lateral and axial frame offsets of patients were 9.1 (range: 3 to 20) mm, 18.1 (range: 5 to 37) mm and 95.3 (range: 25 to 155) mm, respectively. Mean postoperative anteroposterior, lateral and axial frame offset radiographs were 11.8 (range: 2 to 30) mm, 18 (range: 6 to 47) mm and 109.5 (range: 28 to 195) mm, respectively. There was no statistically significant difference between the groups ($p>0.05$).

Conclusion: While measurements taken during operation may lengthen the duration in the operation room, fluoroscopy may provide better images and is easier to perform than digital radiography. On the other hand, there is no difference between measurements taken during perioperative fluoroscopy and postoperative digital radiography..

Key words: Deformity correction; distraction; mounting parameters; spatial frame.

The Taylor Spatial Frame (TSF) (Smith & Nephew, Inc., Memphis, TN, USA) is a multiplanar circular external fixator system that provides 6-axis deformity analysis using a computer-assisted system. The TSF is comprised of two rings connected by 6 telescopic struts. This system is mainly used in the treatment of bone nonunion, defective bone union, correction of deformity and bone fracture.[1-3] Deformity parameters and mounting parameters of the frame are entered into a computer system. Deformity parameters include angulation, translation and shortness which are measured using conventional radiography and rotation which is evaluated clinically or using computed tomography (CT). Frame parameters include dimensions of the applied ring, length of struts and initial lengths of these struts. Mounting parameters define the position of bone according to the frame and the position of the center point of the reference ring according to the origin point and are comprised of four

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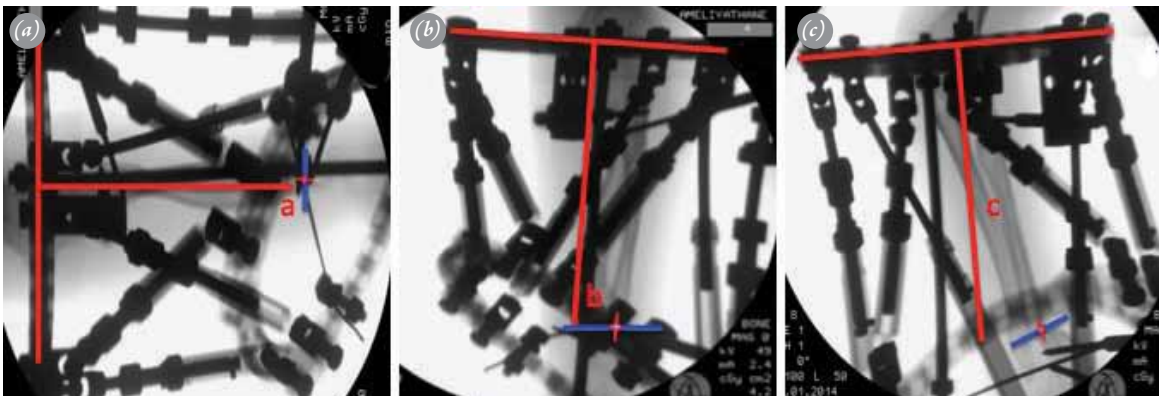

Fig. 1. Measurements taken under fluoroscopy during surgery. The blue line indicates the osteotomy side and the red star in the middle of the blue line indicates the origin. **(a)** Lateral frame offset (a: the distance between the red line [middle of the reference ring] to the red star [origin]). **(b)** Anteroposterior frame offset (b: the distance between the red line to the red star). **(c)** Axial frame offset (c: the distance from the reference ring to the osteotomy side). [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

different measurements: anteroposterior frame offset, lateral frame offset, axial frame offset and rotation frame offset of the reference ring. The anteroposterior frame offset defines the distance of the point of origin to the line crossing the center of the reference ring in the anteroposterior view. Lateral frame offset defines the distance of the point of origin to the line crossing the center of the reference ring in the lateral view. The axial frame offset defines the distance of the point of origin to the reference ring and the rotational frame offset defines the rotation of the reference ring according to the reference bony fragment.

In cases where mounting parameters are inadequate, residual translation-angled deformity may arise. The majority of residual deformities following TSF correction have been reported to stem from erroneous mounting parameters.[4] Several methods have been described to define mounting parameters, including postoperative radiography, perioperative fluoroscopy, and CT.[4-5]

The aim of this study was to test the differences, if any, between mounting parameters measured using perioperative fluoroscopy and postoperative digital radiography.

Patients and Methods

This retrospective study included the 17 extremities of 15 patients (8 male, 7 female) who underwent TSF correction in 2010 and 2011. Mean age at fixator application was 21.9 (range: 10 to 55) years. There were 6 femur deformities, 2 femur fractures, 6 tibia deformities and 3 radius deformities. Mounting parameters were obtained using perioperative fluoroscopy and postoperative digital radiography and the two methods were compared.

Fixators were applied during operation using a method similar to that defined by Gantsoudes et al.[5] The proximal bone fragment was applied vertically, one strut was placed at the midpoints of the anteroposterior plane on a half or complete ring. For the perioperative fluoroscopy measurements, projections of these two struts were superposed under fluoroscopy and the distance of the midpoint to the point of origin was determined using a ring nut and struts. The anteroposterior frame and lateral frame offsets were calculated in the same way. Axial frame offset was calculated using the distance of the anteroposterior reference ring to the point of origin (Fig. 1).

Postoperative digital radiography was used as the second measurement technique. Digital radiographs were taken with the surgeon confirming accuracy and precision of the radiographic positions. The anteroposterior frame offset was calculated using the distance of the line from the midpoint to the point of origin on the anteroposterior view of the digital radiographs. On the lateral view, the vertical line from the midpoint of the reference ring to the point of origin was used to determine the lateral frame offset. Axial frame offset was calculated using the distance from the point of origin to the reference ring on the anteroposterior view (Fig. 2).

The Mann-Whitney U test (SPSS statistical software package; SPSS Inc., Chicago, IL, USA) was used to compare the peri- and postoperative anteroposterior frame offset, lateral frame offset and axial frame offset values. P values of less than 0.05 were accepted as statistically significant.

Results

Mean time to removal of the fixator was 3.5 (range: 3 to 7) months. Mean perioperative anteroposterior frame

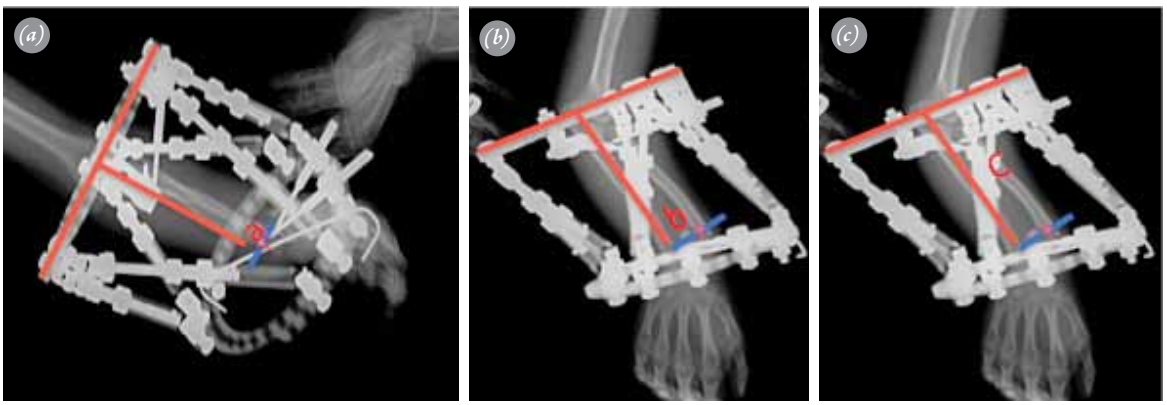

Fig. 2. Measurements taken by digital radiography after surgery. The blue line indicates the osteotomy side and the red star in the middle of the blue line indicates the origin. **(a)** Lateral frame offset (a: the distance between the red line [middle of the reference ring] to the red star [origin]). **(b)** Anteroposterior frame offset (b: the distance between the red line to the red star). **(c)** Axial frame offset (c: the distance from the reference ring to the osteotomy side). [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

offset, lateral frame offset and axial frame offset were 9.1 (range: 3 to 20) mm, 18.1 (range: 5 to 37) mm and 95.3 (range: 25 to 155) mm, respectively. Mean postoperative anteroposterior frame offset, lateral frame offset and axial frame offset were 11.8 (range: 2 to 30) mm, 18 (range: 6 to 47) mm and 109.5 (range: 28 to 195) mm, respectively. There were no significant differences between the two mounting parameter measurements.

Discussion

The TSF is a computer-assisted, hexapodal external fixator system comprised of two frames and 6 struts. It is applied according to the classical Ilizarov principles and used for the correction of deformities. Although the TSF is mainly used for chronic correction of deformities, it can also be used for the acute correction of deformities and fixation of corrected deformity by plate or intramedullary pin.[6]

One ring is chosen as a reference ring and mounting parameters are defined according to the reference ring. The reference ring must be vertical to the applied bone and measurements should be taken according to the vertical ring. Varus/valgus or procurvatum/recurvatum application of the reference ring can lead to the erroneous measurement of the mounting parameters and subsequent residual deformities or defective reduction.

Optimal correction is based on the correct definition of the frame and mounting parameters together with the strut lengths. The parameters must be entered into the software of the computer system. Incomplete entrance of these values leads to erroneous reduction and incomplete correction of the deformity.[5] In the literature, several methods to define mounting parameters of TSF application have been reported, including perioperative methods and postoperative methods using radiographs or CT.[2-5]

Gantsoudes et al.[5] described perioperative measurements and suggested that they were easy and fast to perform. Further advantages include the absence of the need for additional tests or material. Küçükkaya et al.[4] reported that CT provided a better measurement of mounting parameters with a lower rate of residual deformity. The authors also stated that CT may reduce the number of repeated conventional radiographies and prevent treatment delay. Disadvantages include the increased risk of radiation exposure compared to conventional radiography.

In conclusion, mounting parameters must be adequately entered into the computer for TSF application. There are various methods to define these parameters and there is no difference between perioperative measurements and postoperative measurements. One of these two methods may be selected according to the habits and preferences of the surgeon.

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