Research Report

Measurement of Sacroiliac Joint Dysfunction: A Multicenter Intertester Reliability Study

Background and Purpose. Previous research suggests that visual estimates of sacroiliac joint (SIJ) alignment are unreliable. The purpose of this study was to determine whether handheld calipers and an inclinometer could be used to obtain reliable measurements of SIJ alignment in subjects suspected of having SIJ dysfunction. Subjects. Seventy-three subjects, evaluated at 1 of 5 outpatient clinics, participated in the study. Methods. A total of 23 therapists, randomly paired for each subject, served as examiners. The angle of inclination of each innominate was measured while the subject was standing. The position of the innominates relative to each other was then derived. An intraclass correlation coefficient (ICC), the standard error of measurement (SEM), and a kappa coefficient were calculated to examine the reliability of the derived measurements. Results. The ICC was .27, the SEM was 5.4 degrees, and the kappa value was .18. Conclusion and Discussion. Measurements of SIJ alignment were unreliable. Therapists should consider procedures other than those that assess SIJ alignment when evaluating the SIJ. [Freburger JK, Riddle DL. Measurement of sacroiliac joint dysfunction: a multicenter intertester reliability study. *Phys Ther.* 1999;79:1134–1141.]

Key Words: *Measurement, Reliability, Sacroiliac joint.*

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A variety of examination procedures are used by physical therapists to evaluate patients suspected of having dysfunction in the sacroiliac joint (SIJ) region. One category of techniques used to evaluate the SIJ are those techniques designed to assess the anatomical symmetry of bony landmarks on the right and left innominates. Several authors[1–4] have claimed that a finding of asymmetry is a sign of SIJ malalignment and dysfunction.

One of the more common techniques used by physical therapists to assess the alignment of the SIJs involves palpation and assessment of the levels of the anterior superior iliac spines (ASISs) and the posterior superior iliac spines (PSISs).[3,4] According to this hypothesis, an asymmetry in the position of these landmarks, from left to right, is thought to be indicative of an asymmetry in the position of the innominates and is considered a sign of SIJ dysfunction. The asymmetry is described as an anterior or posterior rotation of the innominate[1,2,4,5] and is typically referenced to the involved side. For example, a patient with symptoms in the region of the right SIJ, with a right ASIS lower than the left ASIS and a right PSIS higher than the left PSIS, would have an anteriorly rotated innomimate on the right. Conversely, a patient with symptoms in the region of the left SIJ, with a right ASIS lower than the left ASIS and a right PSIS higher than the left PSIS, would be described as having a posteriorly rotated innominate on the left.

Potter and Rothstein,[6] in a study of subjects with symptoms related to the SIJ region, examined the intertester reliability of measurements obtained with 6 different tests used to compare the relative positions of bony landmarks on the innominates. Four of these 6 tests involved palpation and assessment of the relative positions of the ASISs or PSISs. The other 2 tests involved palpation and assessment of iliac crest levels. They reported the intertester reliability to be poor for all 6 tests, with the percentage of agreement among therapist pairs ranging from 35% to 44%. One explanation for these findings may be that the relative difference (or lack of difference) in the positions of bony landmarks on the left and right innominates was too small to detect visually. One limitation of Potter and Rothstein's study was that they did not calculate kappa coefficients. The percentage of agreement values they reported, therefore, were not corrected for chance. Potter and Rothstein performed chi-square goodness-of-fit tests and determined that all 6 tests did not achieve a 70% agreement level. Sturesson et al[7] measured SIJ motion in 25 patients with SIJ dysfunction and reported translatory motions of less than 1 mm and rotary motions of 2 to 4 degrees. They used intraosseous markers and roentgen

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Figure 1.
Measurement of the angle of inclination of the innominate.

stereophotogrammetric analysis to assess the motion. Kissling and Jacob[8] used a similar method and reported similar values in 24 subjects with no reported SIJ region dysfunction. Because the amount of motion that occurs at the SIJ is small, an alternative method of assessing the anatomical symmetry of the innominates that minimizes the need for visual estimates of the presence and extent of asymmetry may provide more reliable measurements.

Use of handheld calipers and an inclinometer is one method that examiners have used to eliminate the need for a visual estimate of the presence and extent of asymmetry between the positions of the innominates.[2,5,9] The inclination of each innominate in the sagittal plane is measured by first placing the tips of the calipers on the ipsilateral ASIS and PSIS and then using the inclinometer to measure the position of the calipers relative to the horizontal (Fig. 1). The angles of inclination of the 2 innominates are then compared to determine the presence and amount of asymmetry.

Pitkin and Pheasant[9] used calipers and an inclinometer to measure the angle of inclination of the right and left innominates of 144 male subjects with no reported SIJ region dysfunction. They examined the positions of the innominates under 3 conditions: level standing, standing with the right foot elevated, and standing with the left foot elevated. Although they determined asymmetries in the angles of inclination of the innominates with either the left or right foot elevated, they did not establish the reliability of the measurements they obtained.

Cibulka et al[2] used a setup similar to that described by Pitkin and Pheasant[9] to measure and compare the angles of inclination of the right and left innominates in 26 subjects with low back pain. Cibulka and colleagues did not establish the reliability of their measurements and instead referenced a study by Walker et al[10] to support the reliability of their measurements. Walker et al, in a study examining the relationship of postural elements, determined that an inclinometer and calipers could be used to obtain reliable measurements (intraclass correlation coefficient [ICC(1,1)]=.84) of the angle of inclination of only the right innominate in 31 physical therapist students without low back pain. Walker et al did not determine the reliability of the derived measurement of the difference in the angles of inclination of the right and left innominates. Errors in the measurements of the angles of inclination of the right and left innominates, in our opinion, would likely be compounded by deriving the difference in the measurements. Although Cummings et al[5] reported high intertester reliability (ICC[3,1]=.95) of bilateral (ie, left and right) measurements of the angle of inclination, they also did not determine the reliability of the derived measurements of the difference in the angles of inclination. Their study was conducted on 10 female college students. The studies by Cummings et al[5] and Walker et al[10] were also conducted on subjects without low back pain or SIJ region dysfunction and may not be generalizable to people suspected of having SIJ dysfunction.

Because measurements of SIJ alignment obtained with more traditional methods of visual estimation have been shown to have poor reliability, an alternative method would appear to be needed. Although there is some evidence in the literature to support the hypothesis that handheld calipers and an inclinometer can be used to obtain reliable measurements of the angle of inclination of one or both innominates, no studies have been conducted to examine the reliability of the derived measurements of the difference in the angles of inclination of the innominates (ie, the measure used to determine asymmetry). Knowledge of the reliability of this derived measurement would be useful, considering that clinical decisions about treatment of the SIJ are often based on the type of innominate rotation (ie, anterior or posterior) and the amount of asymmetry that is present between the positions of the innominates.[1,2] If handheld calipers and an inclinometer can be used to obtain derived measurements of the difference in angles of inclination of the innominates, treatment progress may be documented more credibly. For example, a decrease in the amount of asymmetry between the innominates following treatment could be one measure of treatment progress or at least an indication of change in an impairment.[2] The purpose of this study, therefore, was to determine whether handheld calipers and an incli-

Table 1.
Characteristics of Participating Therapists

Clinic	No. of Participating Therapists	Years of Experience			Years of Experience Treating Patients With LBP/SIJ[a] Problems			Percentage of Caseload That Consisted of Patients With LBP/SIJ Problems		
		$\bar{X}$	SD	Range	$\bar{X}$	SD	Range	$\bar{X}$	SD	Range
A	5	14.8	7.9	3–24	9.2	4.0	3–13	46	5.5	40–50
B	6	7.2	4.4	2.5–13	6.4	4.5	2–12	40	6.3	30–50
C	4	9	5.3	4–16	9	5.3	4–16	25	0	25
D	5	10.5	5.4	5–18	10.5	5.4	5–18	28	4.5	20–30
E	3	16.7	9.1	10–27	16.0	7.9	10–25	53	5.8	50–60

[a] LBP/SIJ=low back pain/sacroiliac joint.

nometer could be used to obtain reliable derived measurements of the difference in the angles of inclinations of the innominates in people suspected of having SIJ dysfunction.

Method

Examiners

The examiners in the study were therapists who were employed at 5 outpatient orthopedic clinics in Richmond and Charlottesville, Va. Only therapists who regularly treated patients with low back pain were included in the study. Prior to data collection, the clinics were visited by the primary author (JKF) to collect descriptive data on the participating therapists and to instruct the participating therapists in the measurement procedure. Patients with low back pain or SIJ pain constituted 25% to 50% of the caseload at the participating clinics. Table 1 presents descriptive information on the participating therapists.

Each of the participating therapists was given a brief, written description of the study that included the criteria for subject eligibility and instructions on the measurement procedure. The measurement procedure was then demonstrated by the primary author. The therapists were asked to practice the procedure on each other and to begin data collection when the therapists believed they were prepared to use the procedure on patients.

Instrumentation

The angles of inclination of the innominates were measured using large, metal carpenter's calipers and an electronic inclinometer* with a digital readout in degrees (Fig. 2). The calibration of the inclinometers used in the study was checked against a second inclinometer (Dasco Pro Angle Finder Plus Level†) with an analog scale. The readings on the digital and analog inclinometers did not vary by more than 1 degree.

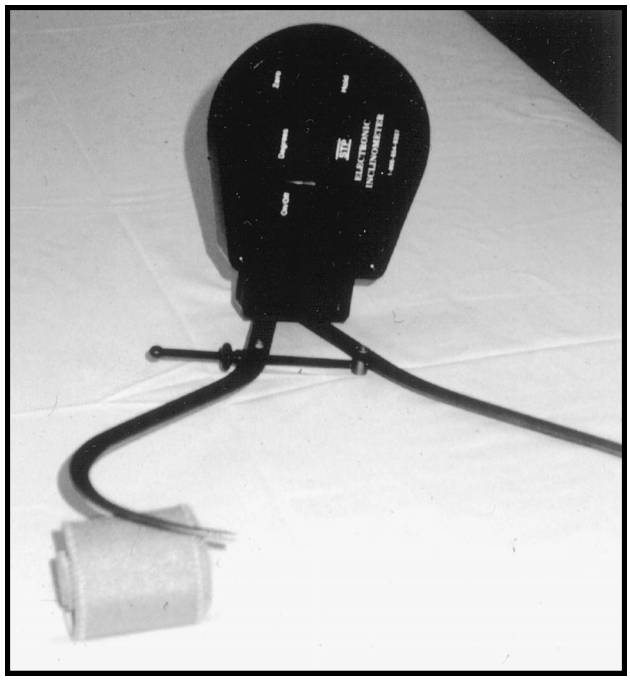

Figure 2.
Carpenter's calipers and an electronic inclinometer.

Subjects

A total of 73 subjects participated in the study. Subjects were included in the study if examination of the SIJ would have been a normal part of the subjects' evaluation or re-evaluation and the subjects did not have a radiographically confirmed leg-length difference or radiographically confirmed scoliosis. The participating therapists determined whether a patient from their caseload was eligible for the study and obtained written informed consent. Characteristics of the subjects are presented in Table 2.

* The Saunders Group, 4250 Norex Dr, Chaska, MN 55318.
† Dasco Pro Inc, 2215 Kishwaukee St, Rockford, IL 61104.

Table 2.
Subject Characteristics (N=73)

Characteristic	Mean (SD) or Frequency, Range
Age (y)	44.8 (14.9), 17–83
Height (in[a])	67.5 (3.6), 60–77
Weight (lb[b])	166.0 (36.1), 98–275
Sex	29 male (40%) 44 female (60%)

[a] 1 in=2.54 cm.
[b] 1 lb=0.4536 kg.

Table 3.
Evaluating Physical Therapists' Reasons for Assessing the Sacroiliac Joint (SIJ) (n=70)

Reason	Frequency
Mechanism of injury indicative of SIJ pathology	13
Pain distribution indicative of SIJ pathology	39
Screening evaluation for patient with low back pain	36
Other	2 (previous SIJ pathology per patient; asymmetry noted in physical examination)

Procedure

Once a subject was admitted to the study, the subject recorded his or her age, height, and weight on a form. The physical therapist who identified the eligible patient (evaluating physical therapist) also completed a checklist that indicated why he or she chose to evaluate the patient's SIJ. The evaluating physical therapist then identified the retest physical therapist from a random list of the participating therapists and recruited a third individual to serve as the recorder.

Table 3 summarizes the evaluating therapists' reasons for examining the SIJ. In 3 instances, the evaluating physical therapist did not supply this information. In approximately 20% of the cases, the evaluating physical therapist chose to look at the SIJ for more than one reason.

The evaluating physical therapist performed the measurement procedure first, out of sight of the retest physical therapist. The evaluating physical therapist instructed the subject to stand barefooted on a sheet of paper (approximately 0.6 × .0.6 m [2 × 2 ft]) with feet shoulder width apart and weight evenly distributed. The evaluating physical therapist then drew an outline of the subject's feet. With the subject maintaining the position of his or her feet, the evaluating physical therapist exposed the subject's ASISs and PSISs. The evaluating physical therapist then palpated the ASISs and placed 0.6-cm (¼-in), adhesive-backed dots on the apices of the ASISs. If the evaluating physical therapist was unable to determine an apex, the therapist was supposed to place the adhesive dot on the center of the ASIS. The evaluating physical therapist then placed adhesive dots on the subject's PSISs using a similar procedure.

Once the adhesive dots were placed, the evaluating physical therapist put the inclinometer on the floor or other easily accessible level surface and pressed a button to zero the inclinometer to the horizontal position. The evaluating physical therapist then positioned himself or herself on one side of the subject, with the recorder on the opposite side. The evaluating physical therapist placed the tips of the metal calipers on the adhesive dots overlying the ASIS and PSIS and then placed the inclinometer on the closed end of the calipers, with the digital readout facing the recorder (Fig. 3). The evaluating physical therapist, therefore, was not aware of (blinded to) the inclinometer reading. Once the positions of the calipers and inclinometer were stable, the evaluating physical therapist instructed the recorder to document the value for the angle of inclination of the innominate. The evaluating physical therapist and the recorder then switched sides, and the evaluating physical therapist placed the calipers and inclinometer as described previously and instructed the recorder to document the angle of inclination for the other innominate. The evaluating physical therapist then placed the inclinometer in an upright position, removed the adhesive dots, and left the room. The subject was able to walk around or sit until the retest physical therapist entered the room. The retest physical therapist asked the subject to stand with his or her feet in the outline made by the evaluating physical therapist. The retest physical therapist then repeated the procedure as outlined previously, with the exception of zeroing the inclinometer. The inclinometer was rezeroed by the retest physical therapist only if it fell on its side during the measurement procedure.

Data Reduction and Analysis

The derived measurements of the difference in the angles of inclination of the innominates were calculated by subtracting the angle of inclination of the left innominate from the angle of inclination of the right innominate. Anteriorly rotated innominates were given positive values, and posteriorly rotated innominates were given negative values. Descriptive statistics on the derived measurements were then calculated. The intertester reliability of the derived measurements was determined using an ICC(2,1).[11] The standard error of measurement (SEM) was then calculated using the ICC value.[12] To further examine the issue of agreement on the presence of innominate rotation, we reduced our data to a

nominal level (1=anteriorly rotated on the right, 2=posteriorly rotated on the right, 3=neutral). We then calculated a Cohen kappa coefficient[13] to determine the level of agreement between the evaluating physical therapist and the retest physical therapist.

Results

The derived measurements of the difference in the angles of inclination of the 2 innominates taken by the evaluating physical therapists and the retest physical therapists (n=146) ranged from −16 degrees (ie, the right innominate posteriorly rotated 16° relative to the left innominate) to +35 degrees (ie, the right innominate anteriorly rotated 35° relative to the left innominate). The mean of the derived measurement of the difference in the angles of inclination of the 2 innominates was 0.9 degrees (SD=6.4). The ICC(2,1) was .27, and the SEM was 5.4 degrees. The kappa value was .18.

Discussion

The ICC describing the reliability of the measurement of the difference in the angles of inclination of the innominates was low. Based on the SEM, there is a 95% probability that the actual value of the difference in the angles of inclination of the innominates was within ±11 degrees of the obtained measurement (ie, 2 SEMs). Considering the mean and standard deviation of the difference measurements obtained in this study ($\overline{X}$=0.9°, SD=6.4), an SEM of 5.4 degrees is too large for the difference measurement to be of use unless the derived measurement exceeds the SEM. For example, if an examiner obtained a difference score of +2 degrees (ie, right innominate anteriorly rotated relative to the left innominate), he or she could be 95% certain that the true value of the difference measurement lies somewhere between −9 and +13 degrees. The examiner, therefore, would not be able to determine, with reasonable certainty, whether one innominate was more anteriorly or posteriorly rotated relative to the other innominate. Because determining the relative positions of the innominates is one of the primary findings clinicians use to choose a treatment for patients with innominate asymmetry,[14–16] the reliability of any assessment of innominate symmetry must include agreement on which innominate is more anteriorly or posteriorly rotated relative to the other innominate.

The Cohen kappa value was .18, which reflects only slight agreement.[17] The difference measurements obtained in this study, therefore, had, in our opinion, unacceptable reliability for determining the presence and type of asymmetry in the angles of inclination of the innominates in addition to having unacceptable reliability for determining the magnitude of difference in the angles of inclination.

Figure 3.
Measurement procedure with inclinometer facing away from examiner.

A more careful evaluation of the data indicated an extreme outlier. For one subject, the difference in the angles of inclination of the 2 innominates was −2 degrees for the evaluating physical therapist and 35 degrees for the retest physical therapist. The magnitude of the disagreement between these 2 measurements, therefore, was 37 degrees. Because the average disagreement between the test and retest measurements was 3.66 (SD=4.48), the data on this subject were removed and the ICC and SEM were recalculated. The ICC increased slightly (ICC=.37), and the SEM decreased to 4.5 degrees. An SEM of 4.5 degrees is still of little value, considering the distribution of the difference measurements ($\overline{X}$=0.9°, SD=6.4) and considering some of the more methodologically sound radiographic studies of SIJ motion.[7,8,18] Sturesson et al,[7] Kissling and Jacob,[8] and Egund et al[18] have reported only 2 to 4 degrees of rotary motion and up to 2 mm of translatory motion at the SIJ in individuals with or without SIJ dysfunction.

The findings of our study are similar to those found in an unpublished study by Lawrence.[19] He used the same procedure to assess the differences in the angles of inclination of the innominates in 63 subjects without low back problems. He reported an ICC(2,1) of .29, an SEM of 4 degrees, and a Cohen kappa value of .16. In addition to obtaining similar reliability coefficients, the difference measurements obtained by Lawrence on the subjects without low back problems were similar to the difference measurements obtained on the patients in our study. To examine this issue statistically, we conducted the Kolmogorov-Smirnov test[20] to determine whether the distribution of the 2 samples (ie, subjects

Table 4.
Number of Subjects From Each Clinic

Clinic	No. of Subjects
A	11
B	3
C	4
D	25
E	30

without low back problems in the study by Lawrence and patients with SIJ dysfunction in our study) were different. The results of the analysis were not significant, indicating that the difference measurements from the 2 samples had a similar distribution and likely came from the same population. Radiographic data also suggest the magnitude of motion present at the SIJ does not vary between individuals with and without SIJ dysfunction.[7,8,18] These data, therefore, suggest that assessments of pelvic alignment may be of little use for identifying individuals with SIJ pathology.

One explanation for the similar findings between our study and that of Lawrence[19] is that motion at the SIJ, with or without dysfunction, is so small that asymmetries cannot be accurately assessed with handheld calipers and an inclinometer. Radiographic studies tend to support this hypothesis.[7,8,18] An unacceptable amount of error occurred despite our attempts to control for some of the more likely sources of error in the measurement.

The instrumentation used in the study was simple and easy to use and, in our opinion, was not likely to be a source of error. The calibration of the inclinometers was checked prior to data collection, and the therapists were instructed in the proper technique for using and zeroing the inclinometer. The procedure used to obtain the measurements was also quite simple, and therapists were instructed to practice the technique until they felt comfortable with it. In addition, the use of paper to standardize the position of the subject, along with instructions to bear weight evenly, addressed a potential source of error in the study.

We believe we controlled for some of the sources of error commonly present when pelvic alignment is assessed visually. We initially believed, therefore, that the procedure we examined was superior to the commonly used visual methods of assessing pelvic alignment. Despite controlling for these sources of error, however, our measurement error was still too great to warrant clinical use of the device.

One possible source of error that we could not control for was the therapist's ability to palpate and locate the apices or centers of the ASISs and PSISs, especially on subjects who were overweight. An analysis of the body mass index of the subjects indicated that 16 subjects had a body mass index between 30 and 40 kg/m^2, indicating grade II obesity.[21] When the data obtained from these subjects were eliminated from the analysis and the ICC and kappa coefficients were recalculated (n=57), the results were essentially the same. The ICC was .28, and the kappa coefficient was .17. The ability of therapists to locate bony landmarks on individuals with obesity, therefore, was an unlikely source of error in the measurements. Furthermore, the palpation skills of the participating therapists were likely good, considering their years of experience in treating patients with low back and SIJ problems (Tab. 1).

The external validity of our study, however, is somewhat limited. A majority of the data that were collected for this study came from 2 clinics; 2 other clinics admitted only a few patients to the study (Tab. 4). The generalizability of our results to the more commonly used technique of palpation and visual assessment of SIJ alignment may also be questioned. Although the technique used in this study required the therapists to palpate the ASISs and PSISs in a manner similar to that done in the clinic, therapists do not typically place adhesive dots on these landmarks and use calipers and an inclinometer to assess SIJ alignment. We developed this systematic technique to gain precision in the assessment of SIJ alignment by minimizing what we believed to be a potential source of error (ie, visual estimation of the positions of the ASISs and PSISs). Although our method appears to be more precise than the commonly used technique of palpation and visual estimation of SIJ alignment, we offer no direct evidence to indicate that this technique yields more reliable measurements.

Clinical Implications

Our results suggest that clinicians should reconsider the tests they use to assess the SIJ. If therapists cannot reliably assess innominate asymmetry by visual estimates or with the use of calipers and an inclinometer, we have to question whether it is appropriate to assess patients for innominate asymmetry. The fact that the radiographic literature indicates such a small amount of movement at the SIJ only compounds our skepticism.

Other authors have proposed different approaches for assessing the SIJ. Cibulka et al,[2] for example, reported high intertester reliability for an examination procedure that used a combination of tests to determine SIJ dysfunction. They defined SIJ dysfunction as being present in a patient if at least 3 of the following 4 tests were positive: standing flexion test, prone knee flexion test, supine long-sitting test, and palpation of PSIS heights in a sitting position. Cibulka et al reported high interrater agreement between 2 physical therapists for determin-

ing the presence of SIJ dysfunction (kappa=.88). That is, the 2 therapists were able to agree on whether patients had 3 or more positive SIJ tests. One limitation of this study was that positive SIJ tests were not referenced to a particular side. For example, the standing flexion test was considered positive when movements of the PSISs were symmetrical (ie, one PSIS moved more cranially than the other PSIS). The 2 therapists, therefore, could have determined that the standing flexion test was positive without agreeing on the type of asymmetry present. One therapist may have found that the right PSIS moved more cranially than the left PSIS, whereas the other therapist may have found that the left PSIS moved more cranially than the right PSIS. Because treatment for SIJ dysfunction is typically directed at the involved or symptomatic side,[22] studies assessing the reliability of data obtained with SIJ evaluation techniques should take into account the type of symmetry present. The external validity of the data from Cibulka and colleagues' study is also limited because only 2 therapists, who were trained in the method, participated in the study.

One category of SIJ tests that has received more attention in the literature consists of SIJ tests that attempt to provoke pain. Potter and Rothstein[6] reported high intertester reliability for iliac compression and gapping tests. Laslett and Williams[23] also reported high interrater reliability for 5 of 7 pain provocation tests. The 5 tests were: iliac compression, iliac gapping, thigh thrust, pelvic torsion right, and pelvic torsion left.

We suggest that therapists use the literature to guide them in the evaluation of the SIJ. Based on the literature, tests used to assess the anatomical symmetry of the innominates do not appear to be useful. Because there is some support in the literature for the reliability of measurements obtained with pain provocation tests, this category of tests appears to be the most useful for therapists evaluating the SIJ.

Conclusion

The results of this study indicate that a procedure using handheld calipers and an inclinometer does not provide reliable measurements of the difference in the angles of inclination of the innominates in people suspected of having SIJ dysfunction. The results of this study are consistent with the findings of published studies that have examined the reliability of visual estimates of SIJ symmetry. Sacroiliac joint symmetry tests do not appear to be useful for detecting whether one innominate is rotated relative to the other innominate. Therapists should reconsider the usefulness of evaluation techniques that rely on the assessment of the anatomical symmetry of bony landmarks of the innominates.

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