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Fibular Position in Individuals With Self-Reported Chronic Ankle Instability

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RESEARCH REPORT

Study Design: Case control study.
Objectives: The purpose of this study was to assess the position of the distal fibula in individuals with chronic ankle instability (CAI).
Background: Recent literature has suggested that a positional fault of the fibula on the tibia may contribute to CAI; however, there is a lack of objective scientific evidence to support this claim.
Methods and Measures: Thirty subjects with unilateral CAI (mean ± SD age, 20.3 ± 1.3 years) and 30 subjects with no previous history of ankle injury (mean ± SD age, 21.3 ± 3.8 years) participated in this study. Subjects completed a pair of subjective functional scales and fluoroscopic lateral images of both the right and left ankles were recorded. The distance from the anterior margin of the distal tibia to the anterior margin of the distal fibula was measured in millimeters. Nonparametric statistics were used to assess the relationship between fibular position and CAI status.
Results: There were significant differences between the CAI and control group ankles ($P = .045$) and within the involved and uninvolved sides of the CAI group ($P = .006$). Those with CAI had a significantly more anterior fibular position on their involved ankle in relation to their uninvolved limb, and the ankles of the control group.
Conclusions: The fibula was positioned significantly more anterior in relation to the tibia in subjects with unilateral CAI. It is unclear if repetitive bouts of ankle instability caused the anterior fibular position or if the more anterior position was a predisposing factor to injury. *J Orthop Sports Phys Ther 2006;36:3-9.*

Key Words: *ankle sprain, fibula, fluoroscopy, tibiofibular joint*

More than 23 000 ankle sprains have been estimated to occur per day in the United States, which equates to 1 sprain per 10 000 people daily.[16] However, it has been reported that 55% of individuals who sprain their ankle do not seek treatment from a health care professional, so the incidence of injury may be much greater.[20] Of particular concern is the high proportion (up to 70%) of patients who will suffer from repetitive ankle sprains and chronic symptoms after initial injury.[20] Chronic ankle instability (CAI) cannot only limit activity but may lead to an increased risk of osteoarthritis and articular degeneration at the ankle.[12]

Mechanical ankle instability (MAI) is one hypothesized cause of CAI.[8,13,25,26] One detrimental effect of MAI is that it can lead to abnormal ankle mechanics.[5] Such abnormal mechanics can be in the form of hypermobility (increased joint laxity)[5] or hypomobility (decreased laxity).[5] Some studies[2,14,18] have reported an increased laxity at the talocrural and subtalar joints in individuals with CAI; however, other studies[7,23,25] reported no increase in ligamentous laxity. The variability in assessment techniques is one contributing factor to the differences in results. One shortcoming of MAI research is the little consideration given to the role of positional faults at the ankle complex in the etiology of CAI.

The relative void in the literature regarding positional faults gives the impression that they do not contribute to residual symptoms or increased risk for reinjury. For joints to move through their full range of motion (physiologic motion) normal arthrokinematic motions must occur.[5] Arthrokinematics describes movement of articular surfaces of a joint as the bones move through a range of motion. Some of the arthrokinematic motions that occur are accessory motions. Accessory motions are movements that the individual cannot voluntarily produce.[5] Examples include rolling and gliding of joints. Positional faults may

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The protocol for this study was approved by the Pennsylvania State University Institutional Review Board.
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contribute to hypomobility by limiting accessory motions, which can alter joint arthrokinematics.[5] Altered arthrokinematics lead to abnormal physiologic motions, distorted state of ligamentous structures, and altered joint function.[5] The combination of these factors may lead to an unstable ankle, thus increasing the risk for reinjury. However, these are theories that need to be examined experimentally.

Mulligan[21] has proposed that some individuals diagnosed with lateral ankle sprains experience an anterior positional fault of the distal fibula on the tibia. Since the original hypothesis proposed by Mulligan[21] there have been several studies that have examined fibular position in subjects with ankle instability.[1,6,7,17,19,24] Results have suggested both anterior[17,19] and posterior[1,7,24] positional faults in those with ankle instability. Therefore, the purpose of this study is to examine fibular position in subjects with CAI compared to a group of individuals without a history of ankle injury.

METHODS

Subjects

Thirty subjects with unilateral CAI (15 males and 15 females; mean ± SD age, 20.3 ± 1.3 years; mean ± SD mass, 72.9 ± 15.8 kg; mean ± SD height, 172.5 ± 10.7 cm) and 30 subjects with no previous history of ankle injury (15 males and 15 females; mean ± SD age, 21.3 ± 3.8 years; mean ± SD mass, 71.9 ± 11.9 kg; mean ± SD height, 172.6 ± 10.7 cm) participated in this study. All subjects were recruited from undergraduate courses until there were an equal number of males and females in the CAI and healthy groups. The sides were assigned so that there were an equal proportion of right- and left-involved ankles in the CAI and control groups. The mean ± SD number of ankle sprains suffered by the CAI group was 5.8 ± 2.7, with a mean ± SD time since the first ankle sprain of 37.5 ± 23.8 months. All subjects reported to an orthopedic clinic for testing.

Subjects filled out an ankle instability questionnaire, which contained the criteria for CAI classification. CAI was defined using a modification of the criteria developed by Hubbard and Kaminski.[15] Inclusion criteria included previous history of unilateral ankle sprain, current giving-way of the ankle, pain, feelings of instability, and decreased function. Subjects were excluded from the study if they had suffered a fracture to either lower extremity, acute ankle sprain within the past 6 weeks, or if they ever had ankle surgery. Additionally, all subjects filled out the Foot and Ankle Disability Index (FADI). The main section of the FADI assesses activities of daily living while the sports scale assesses more difficult tasks that are essential to sport. A 104-point scale is used for the FADI and a 32-point scale is used for the FADI Sport. The scores range from 4 (no difficulty at all) to 0 (unable to do) for each activity rated. Reliability and sensitivity of both components have been previously reported in subjects with and without CAI.[11] Intraclass correlation coefficient (ICC) over a 1-week period for the FADI and FADI Sport was 0.91 and 0.82, respectively. Over a 6-week period the ICC values for the FADI and the FADI Sport were 0.98 and 0.91, respectively.[11] All subjects signed an informed consent agreement approved by Pennsylvania State Universities Institutional Review Board before testing.

Instrumentation

The position of the distal fibula in relationship to the distal tibia was determined by taking a lateral image of both ankles. A Mini 6600 Fluoroscope with a digital mobile C-arm (OEC Medical Systems, Inc, Salt Lake City, UT) recorded images.

Procedures

All subjects completed the FADI and FADI Sport surveys to subjectively assess the function of each of their ankles. Next, the position of the fibula was measured with fluoroscopy. Subjects were positioned in sidelying on the treatment table (Figure 1). The subject's posterior thigh was positioned against a bolster to ensure that the hip was maintained in a neutral position in the sagittal plane. Additionally, a fluid inclinometer was placed on the lateral joint line of the knee to ensure that the leg was kept in neutral and not in abduction or adduction in the frontal plane. The subject's knee was in full extension. Towels were then placed under the leg to maintain neutral position. The foot of the top leg was then placed on the image intensifier of the fluoroscope. The foot was passively positioned in maximum dorsiflexion for testing. Subjects were observed to ensure that no rotations of the lower extremity occurred during testing. The ankle testing order was randomly assigned by 1 examiner, who was blinded to all of the subjects' ankle injury history. The same examiner positioned and made measurements on all subjects.

A lateral image was then recorded. The same procedure was then followed for the opposite leg. A radiographic marker (4.5 mm long) was placed on all ankles to correct for variances in magnification. After the images were printed, measurements were made to determine the position of the fibula. A tape measure was used to make measurements in centimeters with 1-mm increments. The distance between the anterior margin of the fibula and the anterior margin of the tibia was recorded in centimeters and then converted to millimeters (Figure 2). Measurements were made perpendicular to a line drawn vertically from the most anterior point of the tibia (Figure 2).

FIGURE 1. Subject positioning. Subject's foot was positioned in maximum dorsiflexion on the image intensifier of the fluoroscope (OEC Medical Systems, Inc, Salt Lake City, UT).

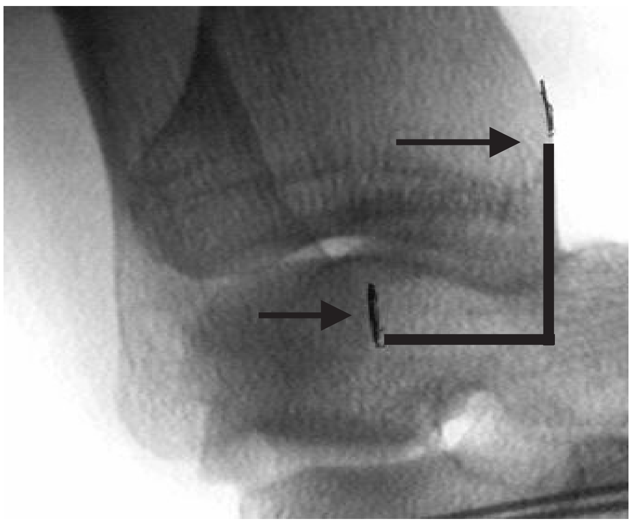

FIGURE 2. Fibular position measurement. The distance between the anterior edge of the distal fibula and the anterior edge of the distal tibia was measured in centimeters and then converted to millimeters.

Reliability Study Procedures Ten healthy subjects were tested for test-retest reliability. The same examiner tested both ankles with the same procedural setup previously described. The procedure was performed on 2 separate days. In addition to test-retest reliability, intratester reliability was calculated by having the same examiner take measures on 2 copies of identical images. Measurements were made on the different images on separate days. Intratester reliability was conducted prior to the beginning of the study and test-retest reliability was conducted after data had been collected.

Data Analysis

The data did not fit a normal distribution (kurtosis, –.374), so nonparametric statistics were calculated. The Wilcoxon signed rank test was used to test for side-to-side differences between ankles within the CAI group and control group. The Mann-Whitney test was used to test for differences between the injured ankle of the CAI group and the matched ankle of the control group, and the uninjured ankle of the CAI group and the matched ankle of the control group. Ankles were matched by side.

For the reliability estimates, $ICC_{3,1}$ and standard error of measurements (SEM) were calculated to determine (1) test-retest reliability for the measures of images taken during different sessions and (2) intratester reliability for the different measures taken off of identical images. The SEM was calculated using the formula: $SD\sqrt{1 - ICC}$.

RESULTS

The Wilcoxon signed rank test revealed significant differences between ankles of the individuals in the CAI group (P = .006). The injured ankle of the CAI group had a mean ± SD fibular position of 14.3 ± 3.1 mm posterior to the anterior edge of the tibia, compared to 16.7 ± 3.4 mm for the contralateral ankle. There were no significant differences between ankles within the healthy group (P = .391). The Mann-Whitney test revealed a significant difference between the injured ankle of the CAI group and the matched side of the control group (P = .045). The injured ankle of the CAI group had a mean ± SD fibular position of 14.3 ± 3.1 mm, compared to 16.1 ± 4.6 mm for the matched side of the control group. There was no significant difference between the uninjured ankle of the CAI group and the matched side of the control group (P = .773) (Table 1).

For test-retest reliability, $ICC_{3,1}$ was 0.98 and SEM was 0.64 mm. For intratester reliability, $ICC_{3,1}$ was 0.92 and SEM was 0.72 mm.

The deficits of the involved ankles of the CAI group identified by the FADI and FADI Sport scores indicate that the injured subjects had functional impairments related to CAI (Table 2).

DISCUSSION

There was a statistically significant difference in fibular position for the subjects with unilateral CAI, suggesting an anterior positional fault was present in those with unilateral CAI. Our effect size was high (0.74) between the ankles of the CAI group, and moderate (0.39) between the CAI ankles and matched control ankles. There have been very little data presented in the literature in regard to the magnitude of bony position associated with positional abnormality that would constitute a positional fault. Based on our effect sizes, greater than a 2-mm difference may be needed to see clinical effects. We do not know if repetitive bouts of ankle instability caused the anterior fibular position or if the position was a predisposing factor to injury in those subjects with CAI.

The findings support previous studies reporting anterior fibular position in subjects with lateral ankle

TABLE 1. Means ± SD (range) of fibular position* for a group with chronic ankle instability (CAI) (n = 30) and a control group (n = 30).

	CAI Group		Control Group	
Measurement	**CAI Ankle**	**Opposite Ankle**	**Matched Ankle**	**Opposite Ankle**
Fibular position (mm)	14.3 ± 3.1 (7.6-20.3)	16.8 ± 3.4 (8.8-26.8)	16.1 ± 4.6 (11.0-24.0)	16.7 ± 3.3 (11.0-24.0)

* The position of the fibula is defined as the distance between the anterior edge of the distal tibia and anterior edge of the distal fibula, measured with a fluoroscopic image.

TABLE 2. Means ± SD and range of Foot and Ankle Disability Index (FADI) and FADI Sport scores (out of 100%) for both groups.

	CAI Group		Control Group	
	CAI Ankle	**Opposite Ankle**	**Matched Ankle**	**Opposite Ankle**
FADI	90.0 ± 5.1 (79.0-98.0)	99.8 ± 0.4 (92.0-100.0)	99.9 ± 0.2 (99.0-100.0)	99.5 ± 0.6 (99.0-100.0)
FADI Sport	80.3 ± 13.0 (44.0-97.0)	99.7 ± 1.3 (87.5-100.0)	99.7 ± 1.3 (94.0-100.0)	98.6 ± 1.4 (94.0-100.0)

Abbreviation: CAI, chronic ankle instability.

instability.[17,19] Mulligan[21] has hypothesized that when the foot is inverted past its normal range, the fibula is pulled forward on the tibia at the inferior tibiofibular joint and a positional fault occurs at the joint. Kavanagh[17] examined this hypothesis in a series of cases. He hypothesized there would be a greater range of anterior-posterior movement possible at the distal fibula if a positional fault of the fibula occurred after an ankle sprain. He reported a significantly greater amount of movement occurred in one third of the subjects with acute ankle sprains.[17] Their sample of 6 acutely injured subjects is small, and only 2 of the 6 had greater movement-per-unit force. With only 2 subjects demonstrating increased movement it is difficult to generalize these results; however, our results in a larger sample appear to confirm the hypothesis that anterior positional fault of the fibula exists.

Mavi et al[19] examined the relationship of the fibula to the tibia using a more objective form of measurement. The distance between the anterior margin of the fibula and the anterior margin of the tibia was measured with MRI. They reported a significant difference between groups with the fibula positioned more anteriorly in the injured group compared to the control group.[19]

Despite this evidence of anteriorly positioned fibula, 3 recent studies reported the fibula to be posteriorly positioned in those with acute ankle sprains.[1,7,24] Eren et al[7] prospectively examined the position of the fibula after acute inversion ankle sprain compared with a control group of uninjured ankles. A CAT scan compared the axial malleolar index.[7] The difference between the injured ankles and control was statistically significant. The results suggest that after an acute lateral ankle sprain the fibula may be positioned posterior in relation to the medial malleolus.[7]

The axial malleolar index was previously measured by Scranton et al.[24] They also reported the fibula to be positioned posteriorly in relation to the medial malleolus in subjects with unstable ankles. Most recently, Berkowitz and Kim[1] reported a posteriorly positioned fibula in subjects undergoing lateral ankle stabilization procedures. They also used the axial malleolar index.[1] The differences in the aforementioned studies and the studies that have reported an anterior fibular position are in the measurement technique. Mavi et al[19] and our current study examined the position of the fibula in direct relation to the tibia in the sagittal plane. The distance between the anterior borders of the distal fibula and tibia were used. Eren et al,[7] Scranton et al,[24] and Berkowitz and Kim[1] measured the relationship in a transverse plane at the talocrural joint. The major limitation with the latter technique is that the measurement of fibular position is based on the position of the talus. Previous research has reported the talus to be anteriorly displaced after an ankle sprain.[4] If the subjects in these studies had an anteriorly positioned talus, the fibula would have appeared to be positioned posteriorly. Our current methods measure fibular position in relation to the tibia without consideration of talar position, which may explain the different results.

Although we reported significant differences in fibular position, not all subjects with CAI demonstrated an anteriorly positioned fibula. When examining the fibular position of each subject, 17 of the 30 subjects with unilateral CAI had an anteriorly displaced fibula (Figure 3). So an anterior positional fault may be present in some, but not in all subjects with CAI. Additionally, there is a wide variability in fibular position (Table 1 and Figure 4).

To help explain why some subjects with CAI present with a positional fault of the distal fibula we propose 2 speculative hypotheses. Acutely, fibular position may be maintained by the effusion accompanying soft tissue injury.[17] Although effusion dissipates rather quickly in most ankle sprains, in some it can persist for days to weeks despite treatment. It may be in these patients that a positional fault is maintained. An alternative and more plausible explanation may be that anterior fibular position is maintained in some subjects by changes in fibularis (peroneal) muscle tone mediated through the gamma motoneuron system. The altered afferent input from musculotendinous and ligamentous mechanoreceptors may contribute to the maintenance of the anterior position of the fibula. The altered afferent input may affect the gamma motor neuron output to the fibularis longus and brevis, contributing further to maintenance of an anterior fibular position.

Distal fibular mobility and position should be examined after ankle injury. If the distal fibula is positioned anteriorly, manual therapy techniques, such as mobilization of the fibula, may need to be considered.[10] Green et al[9] performed a randomized controlled trial of passive joint mobilizations on the talus after acute lateral ankle sprain. They demonstrated that subjects treated with anterior to posterior mobilizations of the talus received fewer treatments to obtain pain-free dorsiflexion range of motion. These results were later supported by Collins et al[3] who also reported significant immediate improvement in dorsiflexion range of motion after mobilization. Additionally, O'Brien and Vicenzino[22] reported immediate reduction in pain, increases in range of inversion, improved outcome, and improvements in function in 2 subjects with acute ankle sprain after treatment with posterior mobilizations of the fibula. The small sample size limits the generalization of the results but necessitates further research examining the effect of mobilization techniques at the distal tibiofibular joint.

This study has some limitations. The fluoroscope records a 2-dimensional image, which limits the ability to identify and measure any rotations of the fibula that may occur. Currently we do not know the validity of the fluoroscope to measure fibular position. We also did not assess subjects for a history of previous syndesmotic injury. Our subjects were asked about past sprains to the lateral ankle only. Syndesmotic injury could disrupt the anterior and posterior tibiofibular ligament, which could also result in a positional fault at the distal fibula. Lastly, our sample size is relatively small and a study with a larger sample size is warranted.

CONCLUSION

We identified an anteriorly positioned fibula in individuals with CAI. Further research is necessary to examine the clinical importance of anterior fibular position in comparison to other potential contributors to CAI, and to identify the minimum amount of positional fault needed to cause ankle joint dysfunction.

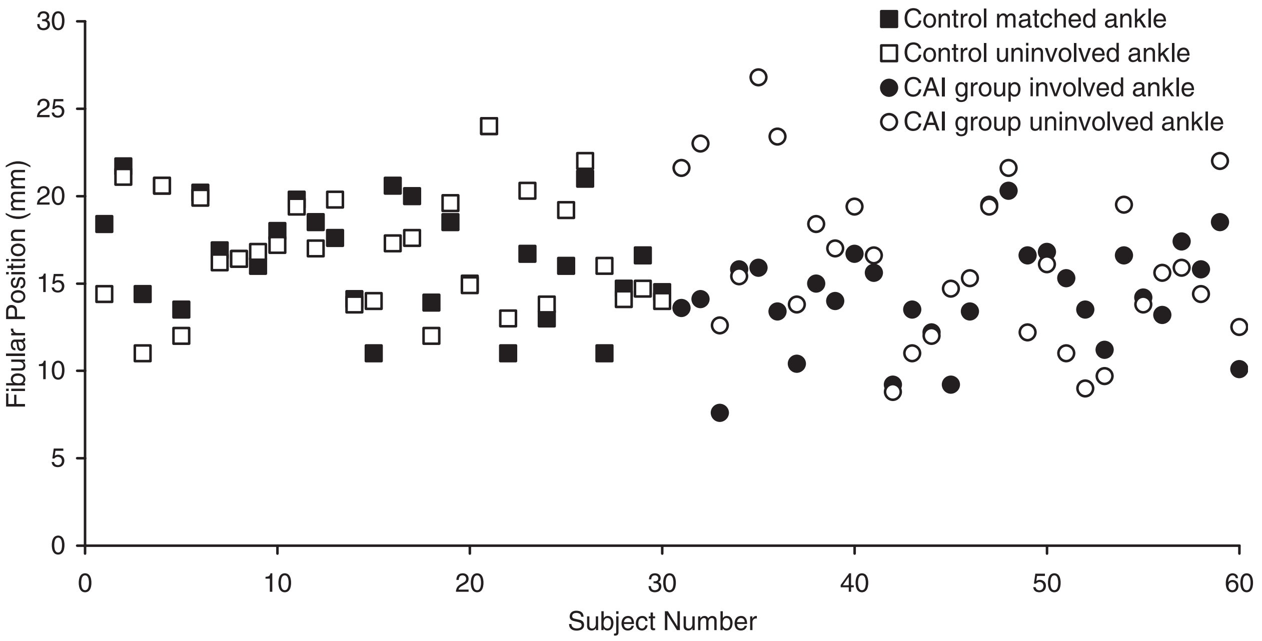

FIGURE 3. Fibular position for both ankles of all subjects (n = 60). A lower number indicates an anteriorly positioned fibula compared to the opposite ankle. Subjects 1 through 30 were in the control group; subjects 31 through 60 had unilateral chronic ankle instability.

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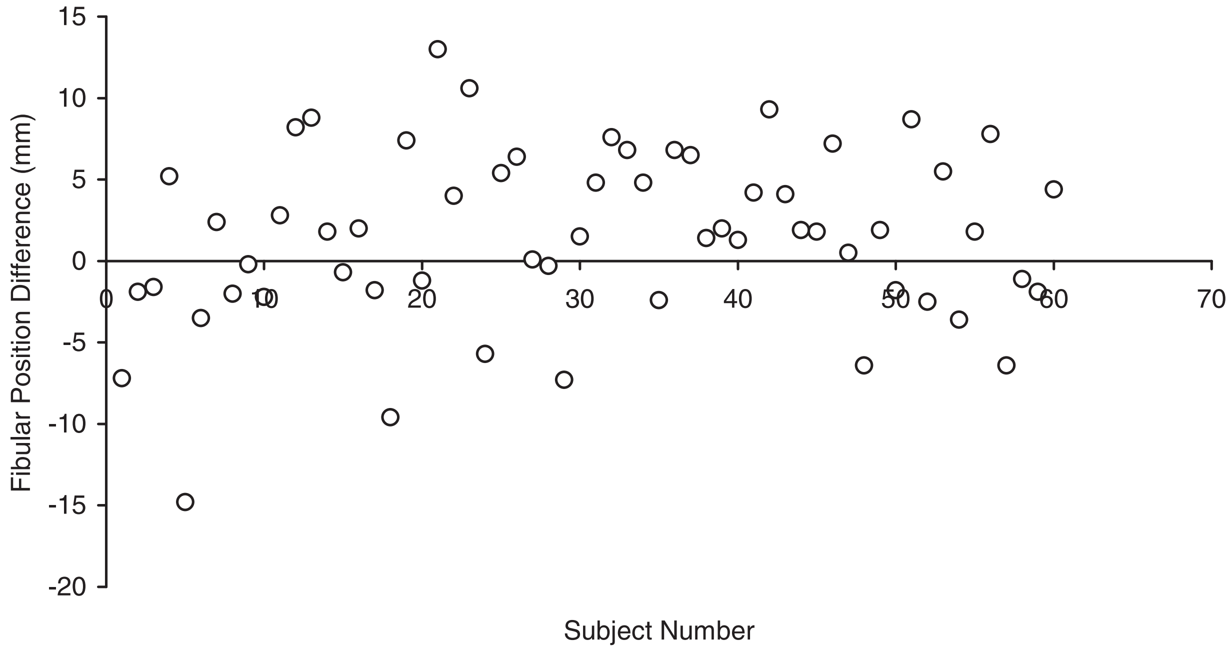

FIGURE 4. Mean fibular position difference* between the right and left ankle of all subjects (n = 60). Healthy group (subjects 1 through 30): mean ± SD difference, 0.6 ± 6.1 mm (range, –14.8-13.0 mm). Chronic ankle instability group (subjects 31-60): mean ± SD difference, 2.5 ± 4.3 mm (range, –6.4-9.3 mm).

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