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Original Article

AOFAS and Karlsson-Peterson scales in evaluating patients treated with modified Broström-Gould and suture tape augmentation for ankle instability: a performance analysis

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Abstract

Objective: The objective of this study was to evaluate the performance of the American Orthopedic Foot and Ankle Society (AOFAS) and Karlsson-Peterson scales in patients with lateral ankle instability treated with modified Bröstrom-Gould (MBG) plasty and suture tape augmentation.

Methods: This retrospective, bicentric, cohort study involved consecutive patients with lateral ankle instability treated with MBG plasty and suture tape augmentation. The Visual Analog Scale (VAS), AOFAS scale, and Karlsson-Peterson scale were used in pre-/postoperative assessments.

Results: Fifty-five patients who underwent MBG plasty and suture tape augmentation were included. Mean preoperative and postoperative VAS scores were 7.1 ± 1.4 and 1.3 ± 1.6 (p<0.001), respectively. Mean AOFAS scores were 61.3 ± 21.1 and 95.4 ± 8.4, respectively (p<0.001). Mean Karlsson-Peterson scale scores were 46.8 ± v14.3 and 95.2 ± v7.9 (p<0.001), respectively.

Conclusions: The Karlsson-Peterson scale showed a better performance than the AOFAS scale in the clinical and functional evaluation of patients with ankle instability treated with MBG plasty and suture tape augmentation.

Level of Evidence III; Therapeutic Studies; Comparative Retrospective Study.

Keywords: Ankle joint; Joint instability; Lateral ligament, ankle; Orthopedic procedures.

Introduction

The combination of suture tape augmentation and modified Broström-Gould (MBG) procedure has been found to be effective in the treatment of lateral ankle instability. This therapeutic alternative appears to be better at increasing mechanical stability of the ankle than MBG alone[1-4]. By increasing the strength and stiffness of the ankle, it can be protected from injury-causing inversion and forced flexion. In a study involving five freshly-frozen cadaveric specimens, the biomechanics of the ankle and foot were compared using native and sectioned anterior talofibular ligaments to simulate instability, which were later reconstructed with a suture tape that reestablished the physiological ranges of motion of the ankle and, partially, the dynamic alignment of the foot; the ligament was found to be protected from elongation during the healing process[5]. Previous studies have shown that seve-

Study performed at the Medyarthros Foot and Ankle Clinic, Center for Sports Medicine and Arthroscopy, Jalisco, Mexico.

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ral years after a Broström procedure, the performance of the ankle is decreased by elongation of the repaired ligament[6], and this can be avoided with suture tape augmentation. Recently, excellent clinical and functional results were demonstrated using the combined procedure, which provides protection against inversion and forced flexion recurrence and reduces the revision surgery risk[4].

In a systematic review of scales used to assess the surgical management of chronic ankle instability in 104 studies[7], 66% and 43% of studies used the ankle and hindfoot American Orthopedic Foot and Ankle Society (AOFAS) scale[8] and the Karlsson-Peterson scale[9], respectively.

The accuracy of the AOFAS scale has not been validated and may show questionable statistical behavior in patients with lateral ankle instability because it uses a mixed system that combines medical evaluation and patient responses[10,11].

Subjective patient-reported ankle instability is the most important diagnostic criterion. Recently, the term "patient-reported outcome measurements" (PROMs) is being used to refer to subjective data presented by the patient and has become the most important tool in patient assessment, surpassing objective evaluation in physical examination[11]. In this context, the Karlsson-Peterson scale has demonstrated a statistically significant correlation between the subjective and objective parameters of ankle stability and function[9] that are used in studies to evaluate the clinical outcomes of patients with ankle instability treated with surgery. The objective of this study was to compare the performance of the AOFAS and Karlsson-Peterson scales in patients with lateral ankle instability treated with MBG plasty and suture tape augmentation.

Methods

A retrospective, bicentric, cohort study was conducted with consecutive patients with lateral ankle instability treated with MBG plasty and suture tape augmentation. The protocol was approved by our Institutional Review Board. The inclusion criterion was subjective patient-reported ankle instability. The diagnosis of lateral ankle instability was confirmed by anterior drawer test and magnetic resonance imaging (MRI). Exclusion criteria were as follows: osteochondral injury, history of ankle surgery or revision surgery, refusal to participate, and patients who could not be reached.

Data were obtained from clinical records and through telephone surveys. Variables of the study were sex, age, affected side, postoperative follow-up time, brand of anchors used in each center, immobilization duration, and rehabilitation time. Postoperative complications and patients with recurrence of ankle inversion and forced flexion mechanism were recorded.

Scales

Data on the clinical and functional variables were recorded using the Visual Analog Scale (VAS), AOFAS scale, and Karlsson-Peterson scale. Scores obtained on the Karlsson-Peterson scale were classified as excellent (95 points), good (80-94 points), fair (50-79 points), and poor (<50 points)[9,12].

Postoperative Care

A posterior cast was used without weight-bearing for two weeks, after which the stitches were removed. A CAM-Walker boot was placed for one week with progressive weight-bearing at tolerance and use of crutches. At week four, the boot was removed and accelerated rehabilitation was initiated with emphasis on proprioception, strength, and range of motion[13]. At week six, jogging was prescribed. At week eight, patient was allowed to return to daily activities.

Statistical Analysis

Data were recorded in Excel® (Microsoft Corporation, Redmond, Washington, USA) being presented as frequency, percentage, mean, and standard deviation. Scales were analyzed using the student's t-test; $p \leq 0.05$ was considered significant. STATA v15.0 software (Stata Corp LLC, Texas, USA) was used.

Results

Fifty-five patients with lateral ankle instability treated with MBG plasty and suture tape augmentation were included (Table 1); mean age was 32.3 ± 10.6 years. Diagnoses were confirmed by MRI; in addition, 25 (45.5%) patients underwent ankle arthroscopy. All patients reported a subjective sensation of instability and presented positive evidence on anterior drawer test. Arthrex anchors (Arthrex, Inc., Naples, Florida, USA) were used in 41 (74.5%) MBG procedures, and Smith and Nephew anchors (Smith & Nephew, Inc., Massachusetts, USA) in 14 (25.5%) MBG procedures.

The mean duration of postoperative immobilization was 2.7 ± 1.4 weeks. In mean, early rehabilitation was started at 10.2 ± 7.6 weeks; mean time taken to return to daily activity after surgery was 22.5 ± 11.7 weeks. A patient with depressive di-

Table 1. Description of 55 patients with lateral ankle instability treated with MBG plasty and suture tape augmentation

Description	n=55
Age (years)[a]	32.3 ± 10.6 (16–58)
Sex (male/female)	22 (40%)/33 (60%)
Affected side (left/right)	28 (50.9%)/27 (49.1%)
Postoperative follow-up (months)[a]	22.4 ± 13.6 (6–55)
Arthrex anchors – MBG	41 (74.5%)
Smith and Nephew anchors – MBG	14 (25.5%)
Postop immobilization duration (weeks)[a]	2.7 ± 1.4 (1-8)
Rehabilitation time (weeks)[a]	10.2 ± 7.6 (2-24)
Time of return to activity[b] (weeks)[a]	22.5 ± 11.7 (3-48)
Ankle inversion mechanism recurrence (yes)	8 (14.5%)

Modified Bröstrom-Gould (MBG).
[a] Data are presented as mean, with the standard deviation and range in parentheses.
[b] A patient who presented complex regional pain syndrome was not included.

sorder presented with complex regional pain syndrome as a complication of the surgical procedure; her rehabilitation adherence was intermittent and, at the 64-week follow-up after surgery, she still had not returned to her daily activities.

In eight (14.5%) of 55 patients, there was ankle inversion recurrence; initial treatment was symptomatic, with rest, application of cold compresses, bandaging, and pelvic limb elevation. After seven days, rehabilitation was continued until complete recovery.

In table 2, the scores on the VAS, AOFAS, and Karlsson-Peterson scales are presented. The mean preoperative and postoperative VAS scores were 7.1 ± 1.4 and 1.3 ± 1.6 (p<0.001), respectively. The mean preoperative and postoperative AOFAS scores were 61.3 ± 21.1 and 95.4 ± 8.4 (p<0.001), respectively. On the Karlsson-Peterson scale, the mean preoperative and postoperative scores were 46.8 ± 14.3 and 95.2 ± 7.9 (p<0.001), respectively.

The contrast between mean preoperative scores on the AOFAS and Karlsson-Peterson scales (61.3 ± 21.1 vs. 46.8 ± 14.3) (p<0.001) may be due to the differences in the parameters of these scales.

Figure 1 shows the preoperative and postoperative scores on the AOFAS scale by category. In panel A, which presents the preoperative evaluation, patients showed high scores in the categories of pain and limitation of physical activity. Regarding the perception of ankle stability, only 28 (51%) patients showed instability. In panel B, there was an overall improvement in all parameters; improvement was significant in the categories of pain, limitation, and use of support, with an increase in maximum walking distance on different surfaces (p<0.05). Likewise, 27 (96%) out of 28 patients with preoperative perception of instability reported stability in the postoperative evaluation.

The patient evaluation results using the Karlsson-Peterson scale are shown in figure 2. In panel A, which presents the preoperative evaluation, 42 (76%) patients reported pain while walking, and eight (14.5%) patients reported severe, constant pain. On the other hand, all patients (n=55, 100%) reported instability, and in 46 (84%) patients, it was manifested when walking. In addition, 63.6% (n=35) of patients reported no problem climbing stairs and 76.4% (n=42) of patients reported difficulty in running. In panel B, which presents the postoperative evaluation, improvement was observed in all categories; 39 (70.9%) patients showed remission of pain, while 14 (25.5%) patients experienced it only during physical activity. It should be noted that in all (n=54, 98%) except one patient, the perception of ankle instability had disappeared (p<0.001).

In the preoperative evaluation using the AOFAS scale, only 28 patients reported instability perception (Figure 1A). In contrast, with the Karlsson-Peterson scale, 55 patients reported instability in at least one parameter (Figure 2A): two patients reported persistent and severe symptoms that required the use of support, thirteen and 33 patients perceived instability when walking on regular surfaces and irregular surfaces, respectively; and two and five patients perceived instability only during physical activity in the last 1–2 months and 12–24 months, respectively. On the other hand, 47 (85.5%) patients reported good alignment (score 10) on the AOFAS scale; the contrast between the mean preoperative assessment scores using the AOFAS and Karlsson-Peterson scales (61.3 ± 21.1 vs. 46.8 ± 14.3) (p<0.001) may be due to the fact that the parameter of alignment is represented on the AOFAS scale but not on the Karlsson-Peterson scale.

Table 3 shows the postoperative evaluation scores on the AOFAS scale by category: 41 (74.5%) of 55 patients reported excellent clinical and functional outcomes; 10 (18.2%) patients reported good outcomes; and only two (3.6%) patients reported fair outcomes. These results are comparable to those reported using the Karlsson-Peterson scale, where excellent clinical and functional outcomes were reported by 41 (74.5%) patients and good outcomes, by 12 (21.8%) patients; only two (3.6%) patients reported fair results and none reported poor outcomes (Table 4).

Postoperative complications included pain in five patients (9.1%), joint stiffness in three (5.5%) patients, and hematoma in one (1.8%) patient, which needed to be drained; superficial wound infection was seen in one (1.8%) patient, being successfully treated with oral antibiotics for seven days and resulting in complete remission. One patient (1.8%) developed complex regional pain syndrome.

Table 2. Results of the VAS, AOFAS, and Karlsson-Peterson scales in 55 patients with lateral ankle instability treated by MBG plasty and suture tape augmentation

Scale	Preoperative Evaluation[a]	Postoperative Evaluation[a]	p-value
VAS	7.1 ± 1.4	1.3 ± 1.6	<0.001
AOFAS	61.3 ± 21.1	95.4 ± 8.4	<0.001
Karlsson-Peterson	46.8 ± 14.3	95.2 ± 7.9	<0.001

Visual Analog Scale (VAS), American Orthopaedic Foot & Ankle Society (AOFAS), modified Bröstrom-Gould (MBG).
[a] Data are presented as mean, with standard deviation.

Discussion

The Karlsson-Peterson scale showed optimal performance in evaluating the clinical and functional outcomes of MBG plasty and suture tape augmentation in patients with ankle instability. Regarding preoperative evaluation, this scale offers a high precision, as it includes six different parameters based on subjective patient-reported instability, thus allowing the magnitude of instability to be defined and the clinical and functional outcomes of the treatment to be evaluated. The AOFAS scale overestimates the clinical and functional parameters of ankle instability by assigning a high score in the pretreatment assessment.

The AOFAS scale is the most frequently used scale in clinical studies, although its validity and reliability in assessing ankle instability has not been determined[7]; critical weaknesses

are the little emphasis placed on instability and the high scores for pain, function, and alignment, resulting in unclear results. It is possible to obtain a high score (greater than 90) in the absence of pain and with a normal range of motion, even when the patient has ankle instability[7]. In a meta-analysis of 88 studies, mechanical laxity and ligamentous insufficiency were found to be related to the subjective feeling of instability, and this was sufficient to determine surgical treatment in 16 of the analyzed articles[7]. Spennacchio et al.[7] proposed that the subjective patient perception is critical in determining the severity of ankle instability and treatment outcomes. Furthermore, AOFAS expressed its opinion on this matter, pointing out that it is not advisable to use the AOFAS scale for clinical and functional assessment of ankle instability[14]. Recent studies have shown lower pretreatment scores on the Karlsson-Peterson scale than on the AOFAS scale[15,16]. Our results are comparable with those reported by Yeo et al.[17]: they examined 48 patients with ankle instability and, in the preoperative evaluation, they found mean scores of 68.7 ± 2.1 on the AOFAS scale and 46.8 ± 2.4 on the Karlsson-Peterson scale. Likewise, in a study involving 24 athletes, in the pretreatment evaluation using the Karlsson-Peterson scale, a mean score of 43.5 (range, 32 to 55) was obtained[18], which is similar to that found in the current study. Self-report of ankle instability is considered enough to determine the need for surgical management, as observed in 16 articles analyzed in a meta-analysis[7]. The discrepancy between the scores obtained on the AOFAS and Karlsson-Peterson scales in the pretreatment assessment of ankle instability is related to the fact that the latter scale includes the most important criterion of self-reported perception of instability[7].

The Karlsson-Peterson scale shows better performance in assessing ankle instability than the AOFAS scale, which overestimates the pretreatment severity score; the former uses a combination of patient responses and physical examination[11]. The main differences between the scales, which impact the total score in the pretreatment assessment of ankle instability, are as follows: the AOFAS scale underestimates ankle instability by assigning it a maximum of eight points; in contrast, the Karlsson-Peterson scale assigns it up to 25 points. Regarding pain, the former assigns it up to 40 points, and the latter, 20 points; in addition, the AOFAS scale assigns the alignment parameter, which is absent in Karlsson-Peterson scale, a maximum of 10 points. Our study is the first in the

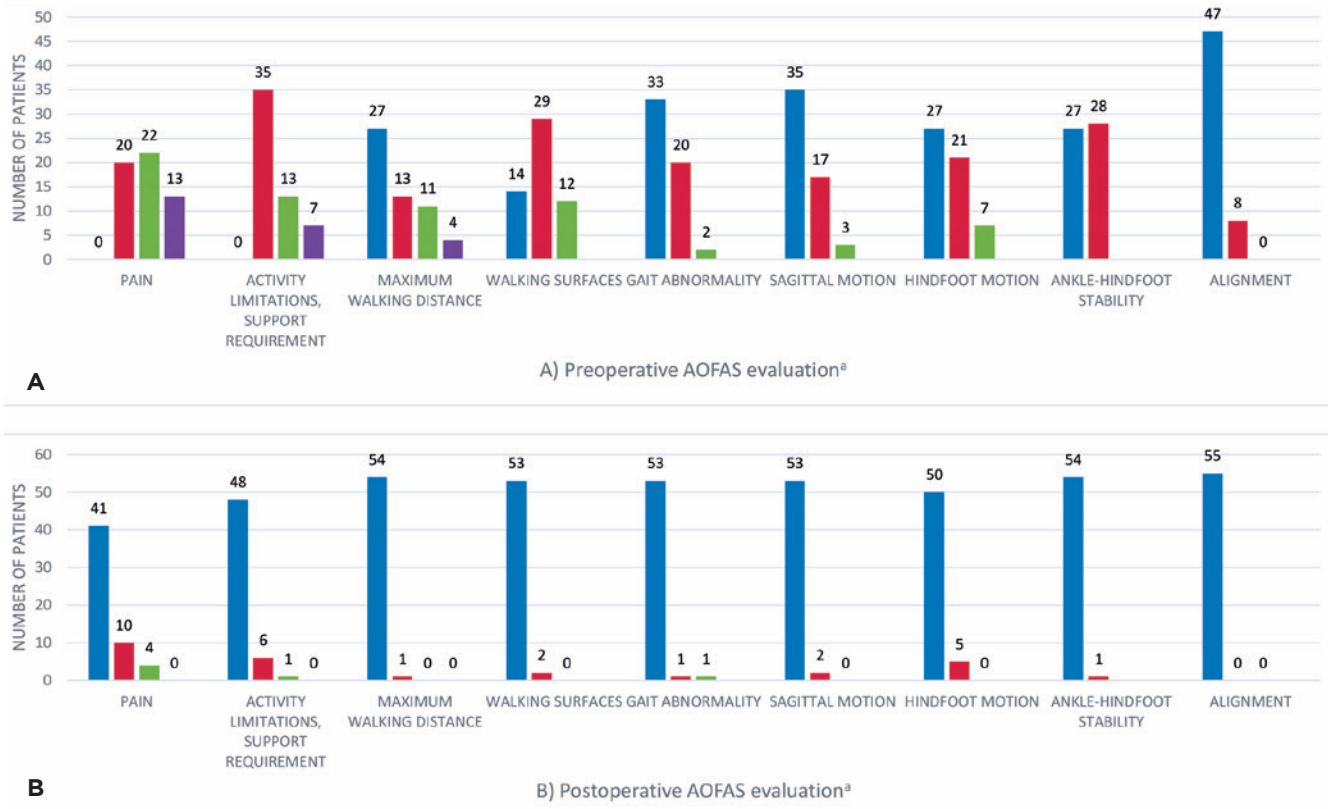

Figure 1. Preoperative (A) and postoperative (B) scores on the AOFAS scale by category in 55 patients with lateral ankle instability treated with MBG plasty and suture tape augmentation. Overall improvement in all parameters is observed; it was significant in the categories of pain and activity limitations, with an increase in maximum walking distance and in walking on different surfaces ($p<0.05$). *Each category relates to the parameters defined on the AOFAS hindfoot scale[13].

literature to compare categories and their impact on the total scores of the AOFAS and Karlsson-Peterson scales when used in the clinical and functional assessment of patients with ankle instability.

Currently, the use of PROMs that include patient-reported outcomes in clinical and functional assessment is gaining popularity[11,14]. The main features of PROMs are the consistent findings and good performance in clinical studies; AOFAS recommends the use of PROMs to assess clinical and functional conditions and treatment outcomes[14]. The AOFAS scale uses a combination of medical evaluation and patient response and is therefore not considered a PROM-based scale[11]; in contrast, there is evidence that the Karlsson-Peterson scale can be considered a PROM-based scale[15-19]. Likewise, the Foot and Ankle Ability Measure (FAAM) and Foot and Ankle Outcome Score (FAOS) scales recommended for foot and ankle are also considered PROM-based scales[11,20] and have been used to evaluate MBG plasty and suture tape augmentation outcomes[1,2,21,22]. Furthermore, in a systematic review, the Karlsson-Peterson, FAAM, and FAOS scales were preferred for evaluating outcomes of surgical treatment of ankle instability[7]. Recently, automatized question banks have been designed for a computer application known as the Patient Reported Outcomes Measurement Information System (PROMIS) (National Institutes of Health (NIH))[14]. It is a standardized system used to assess patient-reported clinical and functional outcomes according to patient responses and integrates objective function and subjective satisfaction information, including function and activities of daily living[11].

The results of MBG plasty with suture tape augmentation are superior to those of standard techniques[3,4,21,23]. Suture tape provides an increased mechanical stability to the ankle that helps prevent recurrence of injury to the lateral ligaments and underlying structures, improves functional stability, and optimizes active rehabilitation[21]. Suture tape augmentation has a positive impact on the patient's self-perception of ankle stability[3]. In our study, 55 patients with ankle instability who underwent MBG plasty and suture tape augmentation were examined; the mean outcome scores at the 22-month follow-up were 95.4 ± 8.4 and 95.2 ± 7.9 on the AOFAS and Karlsson-

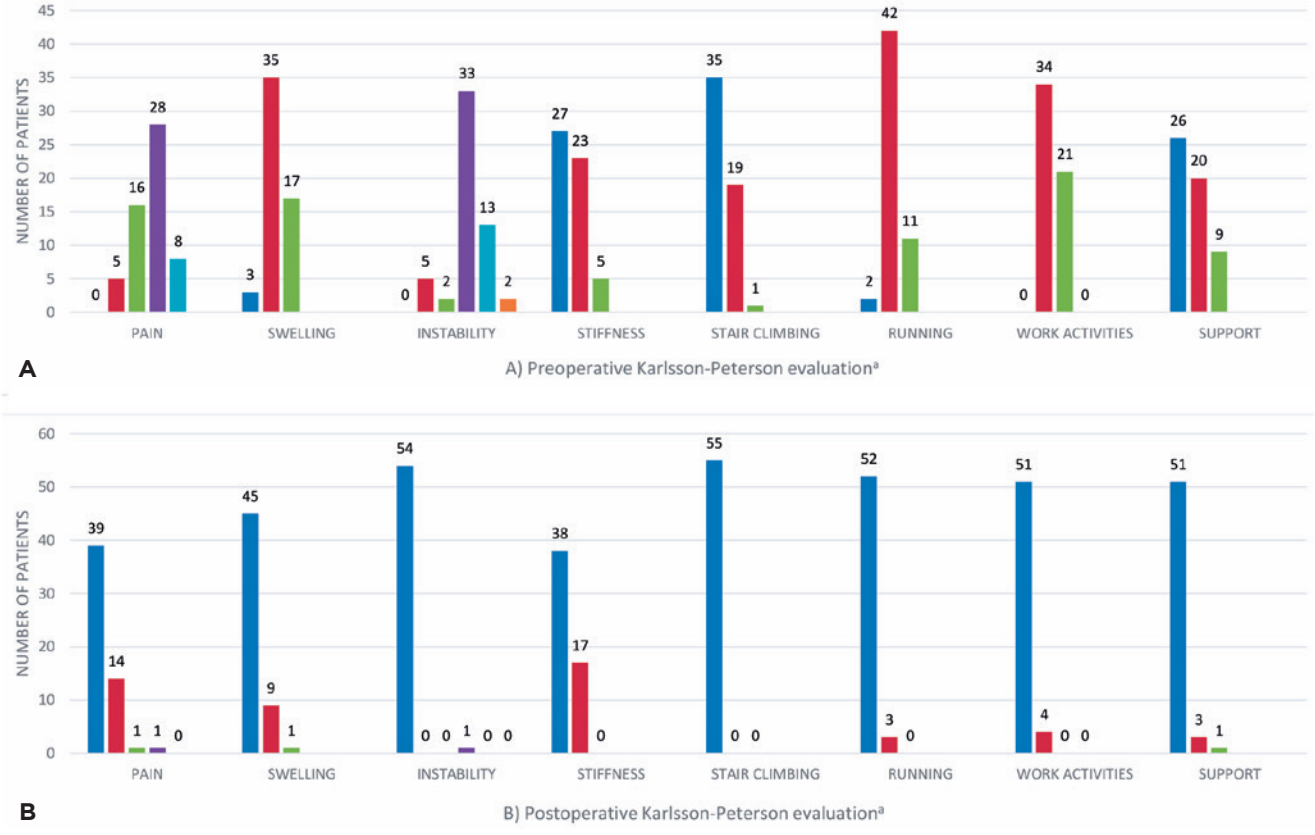

Figure 2. Preoperative (A) and postoperative (B) scores on the Karlsson-Peterson scale by category in 55 patients with lateral ankle instability treated with MBG plasty and suture tape augmentation. In all patients, except for one (n=54, 98%), the perception of ankle instability disappeared (p<0.001).

*Each category relates to the parameters defined on the Karlsson-Peterson scale[12].

Table 3. Results of the AOFAS scale by category in 55 patients with lateral ankle instability treated with MBG plasty and suture tape augmentation

Score: category	n=55 (%)
91-100: excellent	41 (74.5%)
81-90: good	10 (18.2%)
71-80: fair	2 (3.6%)
61-70: poor	2[a] (3.6%)

American Orthopaedic Foot & Ankle Society (AOFAS), modified Bröstrom-Gould (MBG).
[a] A patient presented with a score of 60.

Table 4. Karlsson-Peterson scale results by category in 55 patients with lateral ankle instability treated with MBG plasty and suture tape augmentation

Score: category[a]	n=55 (%)
95-100: excellent	41 (74.5%)
80-94: good	12 (21.8%)
50-79: fair	2 (3.6%)
<50: poor	0 (0%)

[a] Sefton Classification.

Peterson scales, respectively. Yeo et al.[17] examined 48 patients divided into two groups who underwent MBG plasty in open or arthroscopic procedure; the clinical and functional outcomes on the AOFAS and Karlsson-Peterson scales at the 12-month follow-up were evaluated. In the open MBG group (n=23), mean scores of 89.2 ± 2.3 and 73.5 ± 2.8, respectively, were reported. We consider that the superior results achieved in our study are related to the benefit offered by the suture tape augmentation, which led to a positive impact on self-reported stability, resulting in high scores (95.4 ± 8.4 and 95.2 ± 7.9, respectively). Similarity between clinical and functional scores on the AOFAS and Karlsson-Peterson scales can be explained by the fact that ankle instability and pain were already resolved with surgical procedure, which had a positive impact on the patients' perception. On the other hand, in a meta-analysis including three studies with 92 patients who underwent open MBG plasty, the mean score was 90.9 on the Karlsson-Peterson scale[24]; in contrast, we obtained an mean postoperative score of 95.2 ± 7.9. The difference between the scores obtained can be attributed to the benefit of using suture tape augmentation with MBG plasty.

This study has several strengths, such as the large number of patients included and assessment of ankle instability using the Karlsson-Peterson scale, which identifies and categorizes the self-reported ankle instability using PROMs, thus increasing the external validity of data reported in this study. On the other hand, limitations of the study are related to its retrospective design and to the short-term follow-up of the clinical and functional results of surgical management of ankle instability with MBG plasty and suture tape augmentation.

Conclusions

In our study, the Karlsson-Peterson scale showed a better performance than the AOFAS scale in the clinical and functional assessment of patients with ankle instability treated with MBG plasty and suture tape augmentation, which made our study valuable for using this scale in our regular practice. The Karlsson-Peterson scale is a specific, reproducible, and reliable tool that records subjective patient report of clinical and functional features of ankle instability; in contrast, the AOFAS scale overestimates clinical and functional outcomes prior to treatment and underestimates improvement after surgical management. Further clinical studies are needed to validate the performance of the Karlsson-Peterson scale as a PROM-based scale. Modified Bröstrom-Gould plasty with suture tape augmentation is a beneficial procedure that can be adopted in surgical centers for the management of ankle instability.

Author's contributions: Each author contributed individually and significantly to the development of this article: HBTO *(https://orcid.org/0000-0001-6813-4177) Conceived and planned the activities that led to the study, interpreted the results of the study, participated in the review process, performed the surgeries, data collection and approved the final version; ACKM *(https://orcid.org/0000-0003-2457-9654) Performed the surgeries, data collection and approved the final version; ACA *(https://orcid.org/0000-0002-6129-954X) Performed the surgeries, data collection and approved the final version; VJRG *(https://orcid.org/0000-0002-7384-7080) participated in the review process and approved the final version; ROO *(https://orcid.org/0000-0003-3861-2355) Conceived and planned the activities that led to the study, performed the surgeries, data collection and approved the final version; DAZO *(https://orcid.org/0000-0001-9680-6831) Interpreted the results of the study, participated in the review process and approved the final version; LAGC *(https://orcid.org/0000-0002-0812-2497) Conceived and planned the activities that led to the study, performed the surgeries, data collection and approved the final version. All authors read and approved the final manuscript. *ORCID (Open Researcher and Contributor ID).

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