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Original Article

Percutaneous surgical treatment of hallux valgus: retrospective study with 6.5-year follow-up

Luiz Carlos Ribeiro Lara[1], Lúcio Carlos de Azevedo Torres Filho[1], Gabriel Lopes de Faria Cervone[1], Rafael Pacheco Viana[1], Glaucia Bordignon[1], Juan Antonio Grajales[1], Lara Furtado Lancia[1]

1. Hospital Universitário de Taubaté, Taubaté, SP, Brazil.

Abstract

Objective: To analyze outcomes of hallux valgus surgical correction using the Reverdin-Isham technique by means of clinical and radiographic studies.

Methods: We retrospectively assessed 43 feet (38 patients) with moderate to severe hallux valgus treated from June 2009 to July 2014. Mean age at surgery was 59 years; mean postoperative follow-up time was 79 months. Patients were assessed at pre- and postoperative periods both functionally, by the American Orthopaedic Foot and Ankle Society (AOFAS) score, and radiographically, by the hallux valgus angle (HVA), intermetatarsal angle (IMA), distal metatarsal articular angle (DMAA), and shortening of 1st metatarsal bone.

Results: AOFAS scores had a mean increase of 55 points. Mean HVA decreased 14.5°, whereas IMA and DMAA exhibited a mean decrease of 3.8° and 9.7°, respectively. Mean shortening of the first metatarsal bone was 3mm.

Conclusion: The presented surgical technique showed to be effective to correct mild to moderate hallux valgus, resulting in appropriate angle correction angular and significant increase in AOFAS scores.

Level of Evidence IV; Therapeutic Studies; Case Series.

Keywords: Hallux valgus; Minimally invasive surgical procedures/instrumentation; Osteotomy/surgery; Treatment outcome; Patient satisfaction.

Introduction

Hallux valgus, the main deformity of the forefoot, is characterized by a lateral deviation of the hallux and a medial deviation of the first metatarsal, producing a bony protrusion at the metatarsophalangeal joint (MTPJ)[1,2].

Conservative treatment may relieve pain, but it is ineffective in correcting the deformity. Surgery is indicated in symptomatic cases, which are usually associated with difficulty in wearing certain types of shoes. The procedure aims to correct alignment of the first ray, in order to maintain biomechanical functionality of the forefoot[2,3].

Increasingly less invasive techniques have been used for orthopedic treatment. In foot surgery, percutaneous approach stands out due to its potential advantages over open techniques, such as: use of loco-regional anesthesia and of small or punctiform incisions, non routine use of synthesis material, immediate ambulation, low rates of skin complications and of postoperative pain[3-7]. Furthermore, percutaneous approach allows surgeons to intervene on the deformity without directly exposing tissues and anatomical structures, thus reducing trauma to the involved soft parts. Due to the small size of the incision, radiological guidance with fluoroscopy is required[4,6,7].

Percutaneous foot surgery is a recent technique assessed by few studies reporting long-term outcomes in the international literature, which makes it difficult to implement and systematize this technique[5,7].

The aim of this study is to analyze functional and radiological outcomes of percutaneous surgical treatment of hallux valgus using the Reverdin-Isham technique, with a mean follow-up of six and a half years.

Study performed at the Hospital Universitário de Taubaté, Taubaté, SP, Brazil.

Correspondence: Luiz Carlos Ribeiro Lara. 1551 Itália Av., Jardim das Nações, Taubaté, SP, Brazil, Zip Code: 12030-212. **Conflicts of interest:** none. **Source of funding:** none. **Date received:** October 18, 2020. **Date accepted:** November 30, 2020. **Online:** December 21, 2020

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Methods

This study was approved by the Institutional Review Board and registered on the Plataforma Brasil database under CAAE (Ethics Evaluation Submission Certificate) number: 36043320.0.0000.5501.

From June 2009 to July 2014, 92 patients with mild to moderate hallux valgus were operated in our Hospital and in the private clinic of one of the authors. The surgical technique employed a percutaneous approach, as proposed by Isham[6,8].

The study included patients with symptomatic hallux valgus classified as mild or moderate[9] and with a postoperative follow-up longer than five years.

Exclusion criteria were patients with severe hallux valgus, rheumatoid arthritis, neurological disorders, arthrosis of hallux metatarsophalangeal joint radiologically visualized (according to Coughlin and Shurmas[1]), history of previous surgeries or fractures of the forefoot, and postoperative follow-up shorter than five years.

Patients were contacted by telephone, and 38 individuals (46.7% of total) returned for outpatient assessment, totaling 43 feet. All participants were informed on study objectives and signed a free informed consent. Weight-bearing radiographs of the foot were taken in the anteroposterior (AP) and profile incidences, according to routine procedures. Angles were manually measured using a goniometer on the pre- and postoperative AP x-rays. Hallux valgus angle (HVA), intermetatarsal angle (IMA), and distal metatarsal articular angle (DMAA) were obtained[10,11]. Length of the first metatarsal was also assessed through a line drawn from the center of joint surface of the first metatarsal head to the center of the metatarsal-cuneiform joint[7]. The x-rays obtained at public services were analog. For calculating postoperative shortening, the length of distal phalanx of the hallux was used as a scale. Images obtained at private services were digital and had a scale, which facilitated proportional calculation.

All measurements were made by orthopedists belonging to the foot and ankle surgical staff at our service.

Clinical assessment was conducted using the translated version of the questionnaire proposed by the American Orthopaedic Foot and Ankle Society (AOFAS) for disorders of the hallux[12] As requested in the questionnaire, range of motion of hallux interphalangeal or metatarsophalangeal joints was assessed using a goniometer, both in the pre- and postoperative periods.

All postoperative complications were registered on medical records. The following events were considered as complications: surgical wound intercurrences, sensory or motor changes in the hallux, residual callosities and deformities affecting the hallux or the small toes, unpredicted displacement of metatarsal osteotomy, delayed consolidation (absence of bony callus after 8 weeks), relapses, or evolution with osteodegenerative changes.

Surgical technique

Procedures were conducted by a team of three orthopedists specialized in foot and ankle surgery. We used the percutaneous Reverdin technique modified by Isham[6,8] on all 43 feet, associated with proximal phalangeal (Akin) osteotomy[13] and with adductor hallucis tenotomy[4,6].

Patients were placed in the supine position, without using tourniquet, and were under loco-regional anesthesia (5-in-1 blocks) at the ankle[14].

The special material used was a MIS 64 beaver blade, a Wedge 4.1-mm roughing burr, a long Shannon osteotomy burr, and manual bone rasps. The burrs were rotated using a drilling motor operating at 6,000 rotations per minute (Figure 1).

1. Exostectomy – it was performed through a 5-to-8-mm incision on the medial and plantar surface of the first metatarsal (Figure 2). Sectioning was started on a single plane and was made towards the end of exostosis. The joint capsule was then detached using a scraper. Removal of exostosis started using a 4.1-mm roughing burr. The resulting bone fragments were removed by manual expression and cleaned with saline.

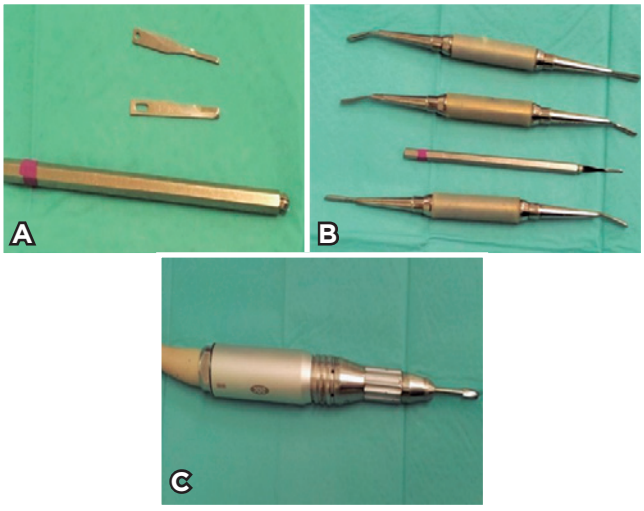

Figure 1. Special materials. A. MIS scalpel handle and its blades B. Manual rasps. C. Handpiece with burr.

Figure 2. Route of surgical access for the conduction of exostectomy and osteotomy.

2. Distal osteotomy of the first metatarsal bone, following the technique described by Reverdin modified by Isham(6,8) – A long Shannon burr (cutting burr) was introduced through the same surgical approach and placed on the medial surface of the metatarsal bone in an oblique direction of 45°. In this position, osteotomy cut was started up to the lateral cortical surface, which was maintained intact to achieve greater stability. By moving the hallux towards a varus alignment, the space generated by the osteotomy cut is closed, leading to osteoclasis of the lateral cortical surface (Figure 3).
3. Adductor hallucis tenotomy and lateral capsulotomy - With a new 2-mm incision at the dorsolateral region of the hallux MTPJ, adductor hallucis tendon and the lateral capsule were sectioned.
4. Proximal phalangeal osteotomy of hallux (Akin)(13) – Through another surgical approach measuring from 3 to 5mm on the dorsal and medial surface of the first phalangeal base, a medial osteotomy was performed using a long Shannon burr without crossing the cortical lateral bone, maintaining a greater stability with osteoclasis after valgus osteotomy of the toe.

Figure 4 shows intraoperative radiological images of the steps described above.

5. Immobilization and postoperative – At the end of the surgery, an elastic bandage was applied, maintaining a slight hypercorrection of the hallux. Bandages were changed weekly during the first four weeks and, in the two subsequent weeks, by the patient. Patients were allowed to walk wearing rigid sole shoes from the first day up to the second postoperative month (Figure 5). Patients were instructed to mobilize the hallux after the first week. Physical therapy was requested after the first postoperative week.

The paired t test was applied to compare pre- and postoperative angle measures and AOFAS scores. This test is based on the assumption of data distribution normality, which was investigated using the Kolmogorov-Smirnov test. Level of significance was set at below 0.05 and represented by "*".

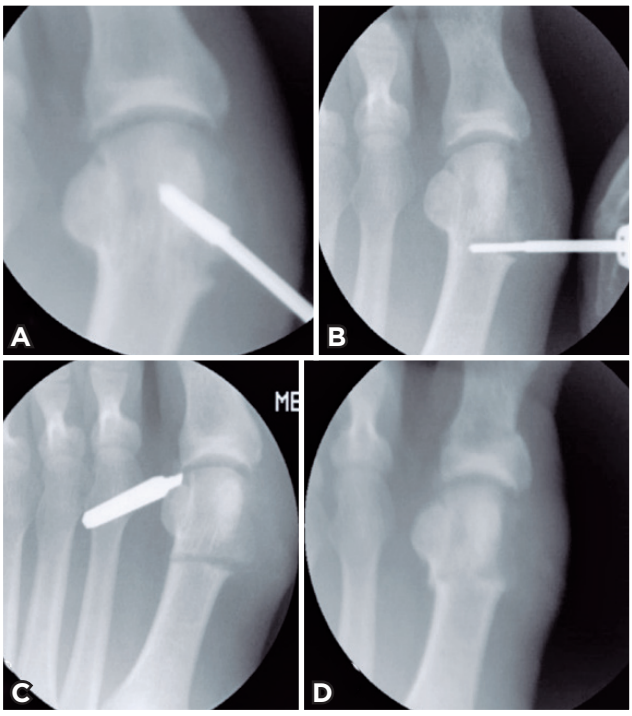

Figure 4. Intraoperative anteroposterior fluoroscopy images used to guide each stage of the procedure. A. Exostectomy B. Distal metatarsal osteotomy C. Adductor hallucis tenotomy D. Proximal phalangeal osteotomy.

Figure 5. A. Postoperative bandage B. Rigid sole shoe.

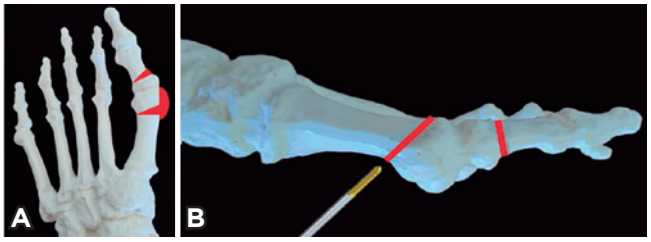

Figure 3. Scheme of the desired result after distal metatarsal osteotomy and phalangeal Akin osteotomy – A. Frontal view, B. Lateral view.

Statistical analyses were performed using the SPSS 20.0 and STATA 12 statistical software.

Results

There was a predominance of women (36 patients, or 94.7%) over men (2 patients, or 5.3%). Mean age at the time of surgery was 59 years (range: 38-83 years). Minimum and maximum postoperative follow-up times were 60 months and 108 months, respectively, with a mean 79 months (6.58 years). The right side was the most affected one, with 25 feet (58.1%), compared with the left side, com 18 feet (41.9%). Five patients presented with bilateral deformity.

In addition to hallux valgus, 37.2% of the operated feet (18 feet) had other associated conditions, which were corrected during the same surgical percutaneous procedure. These conditions were the following: tailor's bunion (2), 2nd supra-adductus toe (7), 2nd and 3rd ray metatarsalgia (3), 2nd, 3rd, and 4th ray metatarsalgia (1), Claw of the 2nd toe (1), claw of the 2nd and 3rd toes (2), claw of the 2nd and 4th toes (1), and claw of all the lesser toes (1).

Mean pre- and postoperative HVAs were 26.5° (SD=7.3°) and 12.0° (SD=6.7°), respectively, showing a reduction of 14.5° (SD=7.8°; 95%CI: -16.9° to -12.1°; p<0.0001*). With regard to IMA, pre- and postoperative means were 14.1° (SD=3.1°) and 10.3° (SD=2.0°), showing a mean decrease of 3.8° (SD=3.4°; 95%CI: -4.8° to -2.7°; p<0.0001*). Mean pre- and postoperative DMAA ranged from 19.6° (SD=8.9°) to 10.0° (SD=7.0°), with a decrease of 9.7° (SD=8.5°; 95%CI: -12.3° to -7.0°; p<0.0001*). Mean values for the three angles were statistically lower in the postoperative period (Table 1).

Mean AOFAS score was 38.7 (SD=11.4) points in the preoperative period and 93.7 (SD=5.1) points in the postoperative period, showing a statistically significant increase (p<0.0001*) of 55.0 points (SD=12.3; 95%CI: 51.2 to 58.8; p<0.0001*) (Table 2).

Mean shortening of the first metatarsal bone was 3mm (SD=0.9mm; 95%CI: 2.7 to 3.3mm), with a minimum of 2mm and a maximum of 5mm.

Complications

Surgical complications are shown in table 3. Moderate restriction of metatarsophalangeal flexion and extension (between 30 and 74°, according to the AOFAS questionnaire) was the most common complication, being present in six feet (13.9%). There was a case of asymptomatic insufficient exostectomy (incomplete smoothing of exostosis[4]) diagnosed radiographically in the postoperative period. A case of pain on the surgical scar was reported (secondary to a burn caused by the burr), as well as a case of hypoesthesia of the medial hallux surface, which was resolved after 4 months, and of delayed consolidation, with the presence of bony callus after 3 months. All of these cases resolved spontaneously with no sequelae.

Figure 6 shows a case of satisfactory correction and a case of complication as examples.

Table 1. Variation in pre- and postoperative measures in the sample of feet

n=43	Assessment			p
	Preoperative	Postoperative	Variation (Post-Pre)	
Hallux Valgus Angle (°)				<0.0001*
Mean (SD)	26.5 (7.3)	12.0 (6.7)	-14.5 (7.8)	
Median	26.0	10.0	-13.0	
Minimum – maximum	12.0 to 42.0	0.0 to 34.0	-30.0 to -2.0	
Intermetatarsal Ângle (°)				<0.0001*
Mean (SD)	14.1 (3.1)	10.3 (2)	-3.8 (3.4)	
Median	14.0	10.0	-4.0	
Minimum – maximum	9.0 to 24.0	7.0 to 16.0	-11.0 to 5.0	
Distal Metatarsal Articular Angle (°)				<0.0001*
Mean (SD)	19.6 (8.9)	10.0 (7.0)	-9.7 (8.5)	
Median	16.0	8.0	-9.0	
Minimum – maximum	5.0 to 45.0	0.0 to 28.0	-30.0 to 6.0	

n: number of feet; SD: Standard Deviation.
p: descriptive level of the Student's t test for paired samples.
Intraclass correlation - Hallux Valgus Angle (0.15; 95%CI: 0.02 to 0.63), Intermetatarsal Angle (0.15; 95%CI: 0.02 to 0.62), Distal Metatarsal Articular Angle (0.44; 95%CI: 0.23 to 0.67).

Table 2. AOFAS scores

n=43	Assessment			p
	Preoperative	Postoperative	Variation (Post - Pre)	
AOFAS score				p<0.0001*
Mean (SD)	38.7 (11.4)	93.7 (5.1)	55.0 (12.3)	
Median	35.0	95.0	60.0	
Minimum – maximum	22.0 to 70.0	75.0 to 100.0	25.0 to 73.0	

n: number of feet; SD: Standard Deviation.
p: descriptive level of the Student's t test for paired samples.
Intraclass correlation: 0.33 (95%CI: 0.00 to 0.99).

Table 3. Complications

Complications	n (%)
Medial displacement of 1st MT osteotomy	1 (2.3%)
MTP edema	1 (2.3%)
Hallux hypesthesia	1 (2.3%)
Burn/painful scar	1 (2.3%)
Insufficient exostectomy	1 (2.3%)
Relapse	1 (2.3%)
Delayed consolidation	1 (2.3%)
Reduced MTP range of motion	6 (13.9%)

MT: Metatarsal; MTP: Metatarsophalangeal; n: Number.

Figure 6. A. Preoperative clinical aspect; B. Preoperative radiographic image; C. Postoperative clinical aspect; D. Postoperative radiographic image; E. Radiographic image from another patient who evolved with medial displacement of the metatarsal head.

Discussion

Mean AOFAS score was 38.7 points before surgery and reached 93.7 after surgery, showing a mean increase of 55 points. In a study previously published by the same authors of the present study and involving the same surgical technique, but with a shorter follow-up, mean variation was 40.9 points[3]. This improvement in scores may be justified by the fact that we have already overcome the learning curve, thus improving our results. In the searched literature, postoperative values obtained by the questionnaire were close to 90 points[7,16-20], reaching up to 95 points, according to Restuccia et al.[21] and Reyes et al.[22]

HVA correction followed the procedures described by most studies that used the same technique, resulting in a mean decrease of 14.5°[7,18-20]. IMA had a mean decrease of 3.8°, a value similar to that found by other authors[7,19,21] and comparable to that reported in studies using the Bosch technique[16, 17].

The Reverdin-Isham technique allowed us to achieve a significant correction of DMAA, with a mean of 9.7°. This result was superior to that of other studies using the same technique[17,20,21]. Compared to studies that used the Bosch technique[16,17,23], a greater DMAA correction with a smaller surgical approach. Since the Reverdin-Isham technique is an intracapsular technique, it is not recommended in isolation on feet with an intermetarsal angle higher than 18°, because the capacity of correction of this technique is relativity lower than that of extracapsular techniques[4]. For this reason, patients with severe hallux valgus were excluded from the study.

Excessive shortening of the first metatarsal bone leading to imbalance of the metatasal formula is one is one of main factors causing transfer metatarsalgia in the long-term post-operative period. According to Isham, the expected value for shortening with this technique would be 5 mm[24]. Prado et al. found 7mm of shortening, and metatarsalgia was present in 25% of their cases[9]. Our mean shortening was 3 mm, and there were no complaints of metatarsalgia after the procedure. The fact that we used burrs with a thickness of 2 or 2.2mm may have led to a lower shortening of first ray, thus maintaining a harmonious metatarsal formula and a painless foot.

The decrease in MTPJ range of motion (included in the AOFAS questionnaire) is one of the main complications of hallux valgus surgery[7,22,25]. In the present study, it was the most common complication, occurring in six feet (Table 3) that showed moderate limitation in flexion-extension range (between 30 and 74°). This fact may be justified by the fact that, in intra-articular osteotomies, correction is maintained by postoperative immobilization, favoring mobility limitation. According to Carvalho et al.[19], when performing osteotomy and extra-articular fixation of the metatarsal bone, motion can start earlier, leading to a greater mobility gain. In a study with 189 patients treated with the percutaneous Reverdin-Isham technique, Bauer et al.[26] observed that MTPJ range of motion had a mean limitation of 15° in the postoperative period, corresponding to a 17% decrease in total range of motion. A decrease of 10-20% may be expected in open osteotomies[27] and of nearly 15 degrees in percutaneous Reverdin-Isham osteotomy[7,9,20].

Other complication present in our study was medial displacement of first metatarsal osteotomy. Although not being frequent, this deviation is described in other studies[19,28] and may have been caused by instability inherent to the osteotomy, to creating an excessive medial-based wedge, and poor postoperative immobilization.

Hallux hypoesthesia occurred in one foot, evolving with complete recovery of symptoms in the third postoperative month. According to Prado et al.[9], this complication reached 30% of feet in the immediate postoperative period, but remained symptomatic in only 7% of the cases.

Skin burn at the site where the burr was introduced occurred in one foot, and evolved with good healing with no adherences. In another study of ours, this was the main complication[3]. We attributed this fact to the learning curve of the technique and may have occurred due to inadequate handling of the end mill and by the prolonged contact of this tool with the skin.

In the literature, the rate of infection after percutaneous foot surgery ranged from 0% to 3.5%[27,29]. There was no report of this event in the present study, and we believe that it may be justified by the little aggression to tissues and minimum bone exposure, according to Prado et al.[9].

Only one case of delayed consolidation was visualized, with complete ossification in the postoperative sixth month. In the remaining cases, osteotomy consolidation was radiographically proven nearly the eight postoperative week.

In order to reduce skin complications (such as infection and burns) and prevent delayed consolidation caused by osteonecrosis at the osteotomy site, we should avoid overheating of the end mill during its use. This may be minimized with the non-use of tourniquet and intermittent irrigation with saline[29].

There was only one case of recurrence requiring a new intervention. Recurrence of deformity is little frequent with this technique, as observed by other authors[7,9,19]. Our study did not observed other complications described in previous studies with the percutaneous technique, such as reflex sympathetic dystrophy, pseudarthrosis, necrosis of skin or of first metatarsal head, and deep vein thrombosis[7,9,18,30].

The main strength of this study is its follow-up. Minimum follow-up was established as 5 years, which allowed us to observe the long-term evolution of each patient, including whether there were complications or recurrences. Other positive point was the fact that our pre- and postoperative assessment covered both objective radiographic measurements (variations in angle and metatarsal length) and patients' functional assessment (clinical assessment and AOFAS questionnaire).

The AOFAS questionnaire was used in a version translated from English, since this questionnaire has not been officially validated for the Portuguese language yet. It is know that this score has little validation in the literature due to its limitations in clinical assessment[30-32]; however, it is still one of the most used assessment methods. For this reason, the use of this questionnaire allowed us to compare our clinical and radiological results with a wider literature.

Some limitations of the study should be mentioned. The entire pre- and postoperative assessments were performed by the same surgeons' team that conducted the procedures, which may represent a performance bias. Data were collected by more than one examiner. Furthermore, many patients did not return for follow-up, which resulted in a relatively small sample (attrition bias) and did not enable sample calculation. This may be justified by patients' difficulties to reach our service, since it is a public hospital with a great coverage. Patients with arthrosis were not included in the present study because, as previously mentioned, joint stiffness is a possible complication of the technique applied in this study. By excluding these patients, we are preventing further damage to an already compromised joint. Since this is a retrospective study to evaluate the outcomes of a single surgical technique, there was no control group to compare results.

Conclusion

The percutaneous Reverdin-Isham technique showed to be effective in correcting mild to moderate hallux valgus, promoting a significant clinical-functional improvement and adequate radiological correction during a mean postoperative follow-up of 6.5 years. This is a potentially less invasive procedure resulting in lower rates of complications compared with open surgery. The popularization of this technique and appropriate surgeon's training will lead to the development of additional studies with long-term follow-ups for first ray deformities.

Authors' contributions: Each author contributed individually and significantly to the development of this article: LCRL *(http://orcid.org/0000-0003-1158-2643) conceived and planned the activities that led to the study; wrote the article; interpreted the results of the study; participated in the review process; approved the final version; LCATF *(https://orcid.org/0000-0002-0778-2506) interpreted the results of the study; participated in the review process; approved the final version; GLFC *(https://orcid.org/0000-0001-5470-8379) interpreted the results of the study; participated in the review process; approved the final version; RPV *(https://orcid.org/0000-0002-1775-6870) interpreted the results of the study; participated in the review process; approved the final version; GB *(https://orcid.org/0000-0001-5273-4303) interpreted the results of the study; participated in the review process; approved the final version; JAG *(https://orcid.org/0000-0003-4652-4400) interpreted the results of the study; participated in the review process; approved the final version.

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