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Standardization of the Radiographic Study of the Foot Using the Niza Box

Padronização do estudo radiográfico do pé pela caixa Niza

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Abstract

Objective This study proposes the Niza box, a device created to reduce interpretive errors among professionals and facilitate the correct positioning of structures by standardizing orthopedic radiography of the foot in anteroposterior, loaded, and Saltzman views.
Methods Descriptive study based on material collected at an Orthopedics Ambulatory from a tertiary service in a large Brazilian city. The X-ray device was a Lotus X, model HF 500 M, 500 milliamperes and 125 kilovolts capacity, 100 cm focus-film distance, and 24×30 cm radiographic chassis. Device controls were set at 100 mA, 5 mA/sec, and 60 kilovolts, depending on the variable size of the foot. The same team of previously trained radiography technicians performed the tests under the authors' supervision. The chassis were positioned in three specific Niza box spaces per the proposed incidence. Data from 50 images from people between 18 and 70 years old were analyzed.
Results Radiographs taken using the proposed device usually had a satisfactory quality, allowing correct identification of the anatomical elements of the foot and ankle and angular reconstruction. Small image variations due to foot size were acceptable and expected, allowing radiograph standardization.
Conclusion The Niza box is a good method for minimizing interference and avoiding radiographic interpretation errors, providing quality and agility to the examination, and reducing cost and unnecessary repetitions. It is an innovative, low-cost device made of recyclable and biodegradable material.

Keywords
- foot joints
- foot
- radiography
- radiology

Resumo

Objetivo Este estudo propõe a utilização da Caixa Niza, dispositivo criado com a finalidade de diminuir os erros interpretativos entre profissionais e facilitar o correto

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posicionamento das estruturas radiografadas ao padronizar as incidências radiográficas ortopédicas do pé anteroposterior, perfil com carga e Saltzman.

Métodos Pesquisa descritiva, material coletado em Ambulatório de Ortopedia em serviço terciário de cidade brasileira de grande porte. Utilizado aparelho de radiografia marca Lotus X, modelo HF 500M, capacidade de 500 miliamperes e 125 quilovolts, distância foco-filme de 100cm, chassi radiográfico 24×30 cm e os comandos do aparelho ajustados para 100 mA, 5mA/seg e 60 quilovolts dependendo do tamanho variável dos pés. Exames realizados pela mesma equipe de técnicos em radiografia previamente treinados com supervisão dos autores. O chassi é posicionado em três espaços específicos da Caixa conforme a incidência proposta. Foram analisados dados de 50 imagens de pessoas entre 18 e 70 anos.

Resultados A avaliação das radiografias após utilização do dispositivo proposto ocorreu de modo geral com qualidade satisfatória, permitindo correta identificação dos elementos anatômicos do pé e tornozelo e reconstrução angular. Pequenas variações nas imagens devido ao tamanho dos pés são aceitáveis e esperadas, sendo possível perceber padronização das radiografias.

Conclusão A Caixa proposta se mostra um bom método de minimizar as interferências e evitar erros de interpretação radiográfica, proporcionando qualidade e agilidade ao exame, diminuindo custo e repetições desnecessárias. É inovador, um dispositivo de baixo custo, de material reciclável e biodegradável.

Palavras-chave
- articulações do pé
- pé
- radiografia
- radiologia

Introduction

Foot anatomy has paramount importance for the human skeleton. It consists of bones, joints, and ligaments acting as a lever for propulsion, providing adaptation to different surface types, and supporting the body's weight.[1–3] Foot fractures represent a large portion of orthopedic conditions, affecting different ages and both genders. Its treatment and follow-up, often within the hospital and with sick leave from work, represent a significant public health cost.[2]

The successful treatment of foot fractures is multifactorial, including an appropriate physical examination, complete history, standardized radiographic study, and supplementary imaging if required.[4] Radiography is the initial imaging of choice for most orthopedic conditions. It is essential to the clinical examination for diagnostic elucidation and treatment selection.[5,6]

For foot conditions, radiology aims at the part of the limb affected by the fracture. The following views are highlighted: 1. Anteroposterior (AP), for better visualization of tarsal, metatarsal, and phalangeal bones; 2. Profile, for rearfoot, midfoot, and forefoot with or without load; 3. Oblique, allowing visualization of the midfoot, forefoot, and tarsometatarsal joint; 4. Harris, to demonstrate the calcaneal tuberosity and the posterior talar articular surface; 5. Canale, allowing visualization of the talar neck; and 6. Saltzman, a hindfoot axis to the tibial axis.[7,8] Excellence in radiographic parameters and classic treatment-conducing measurements require proper techniques, correct equipment, and test standardization. These factors allow a more precise visualization of the elements studied, bone relationships, orthopedic angles, and joint axes in different foot conditions.[9]

AP and profile radiographic views of the foot allow the assessment of fractures and their deviations, ligament injuries (such as Turcot lesion), alignment, and orthopedic conditions in the forefoot, such as hallux valgus.[6,9] The Saltzman view establishes the relationship between the tibia and the calcaneus at the coronal plane in diseases like pes planovalgus, equinovalgus foot, and others caused by hindfoot misalignment.[10]

This study proposes the Niza box, a device created by the authors to standardize foot orthopedic radiography in AP, loaded profile, and Saltzman views to reduce interpretive errors among professionals and facilitate the correct positioning of the structures for analyses.

Materials and Methods

This study is a description to introduce the Niza box as a standardization device for AP, loaded profile, and Saltzman views to radiograph the human foot. The standardization of the radiographic technique in this study was tested on 50 subjects aged between 18 and 70 years in the proposed views, seeking identical feet positioning, precise reference points definition, and high-quality images.

We collected the material at the Foot and Ankle specialized orthopedics outpatient clinic from a tertiary service in a large Brazilian city. Radiographs were taken with a Lotus X X-ray device (Fixed X-Ray HF500M LOTUS, Curitiba, PR, Brazil) with 500 milliamps and 125 kilovolts capacity by a team of radiography technicians previously trained, used to the material, and supervised by the authors. The previous box demarcation allowed a better adaptation to the patient's positioning.

The previously defined radiographic factors were a focus-film distance of 100 cm and the device controls set at

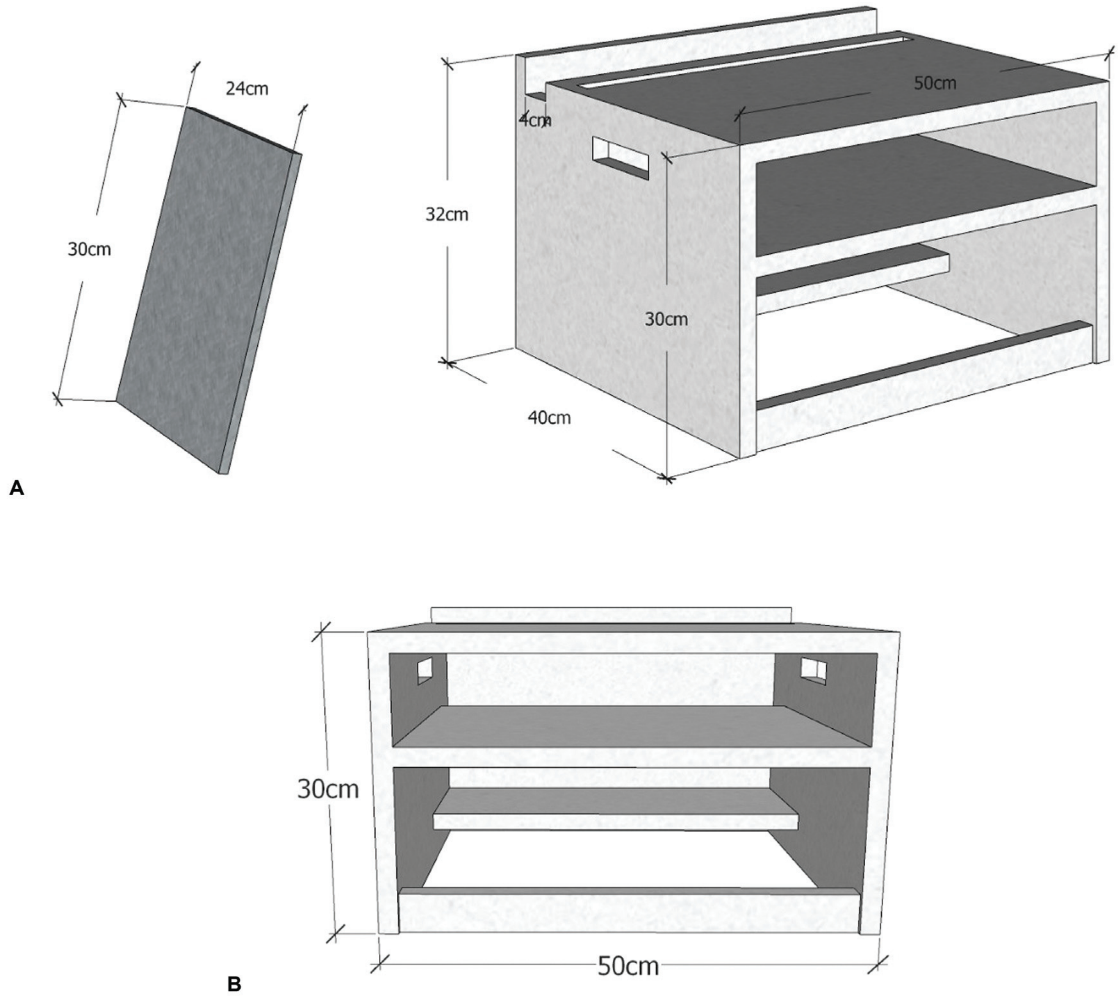

Fig. 1 The Niza box and its exact measurements for the angulation and standardization required for the study. On the left side, radiographic chassis placed according to the proposed view.

100 mA, 5 mA/sec, and 60 kilovolts per the variable size of the feet.

The box measures 40 cm x 30 cm x 50 cm and has specific platforms for positioning the 24 × 30 cm radiographic chassis. This ensures uniformity, device preservation, correct spacing, and patient's comfort and balance. The chassis is put inside the box for AP radiographs, perpendicular to it for profile views, and oblique to it for Saltzman views. Chassis positioning is demonstrated below (►**Fig. 1)**.

1) Anteroposterior view
a) Positioning: the patient is placed in an orthostatic position on the top of the box with the feet parallel to each other, allowing a simultaneous bilateral examination and reducing unnecessary irradiation.
b) Central beam: in a vertical plane at a 10°-angle posteriorly towards the heel, anteroposterior direction, and craniocaudal orientation. The midfoot views allow visualization of phalanges, metatarsal, medial, intermediate, lateral cuneiforms, cuboid, and navicular bones; (►**Figs. 2** and **3**).
2) Loaded mediolateral profile view
a) Positioning: the patient is placed in an orthostatic position for separate examination of the right and left sides in a site marked for the foot.
b) Central beam: perpendicularly to the sagittal plane of the body with mediolateral orientation and direction, focusing the navicular bone region. It allows the visualization of the distal end of the tibia and fibula, and the metatarsals are almost overlapped; only the fifth metatarsal bone tuberosity is seen laterally in the image. The patient stands on top of the box in orthostasis, loading weight on the examined foot (►**Figs. 4** and **5**).
3) Saltzman view
a) Positioning: the patient is placed in an orthostatic position on the top of the box with the feet in the markings and parallel to each other.
b) Central beam: at a 20° angle to the ground, focusing the posterior region of the calcaneus between the two feet in the center of the chassis, in a craniocaudal orientation and posteroanterior direction, approximately 5 cm from the plane of foot support. The chassis is positioned in the specified space, perpendicular to the central beam (►**Figs. 6** and **7**).

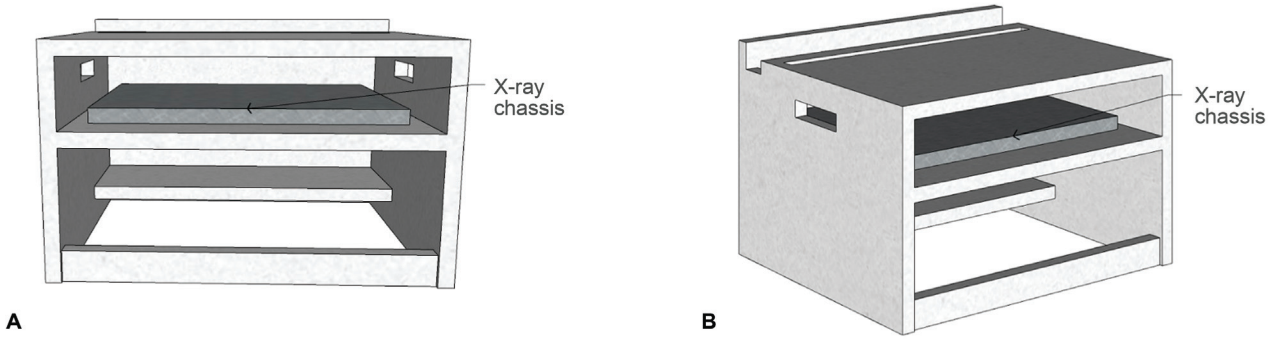

Fig. 2 Configuration for the anteroposterior view with the chassis inside the box.

Fig. 3 Correct positioning for the anteroposterior view.

Fig. 5 Correct positioning for the loaded profile view.

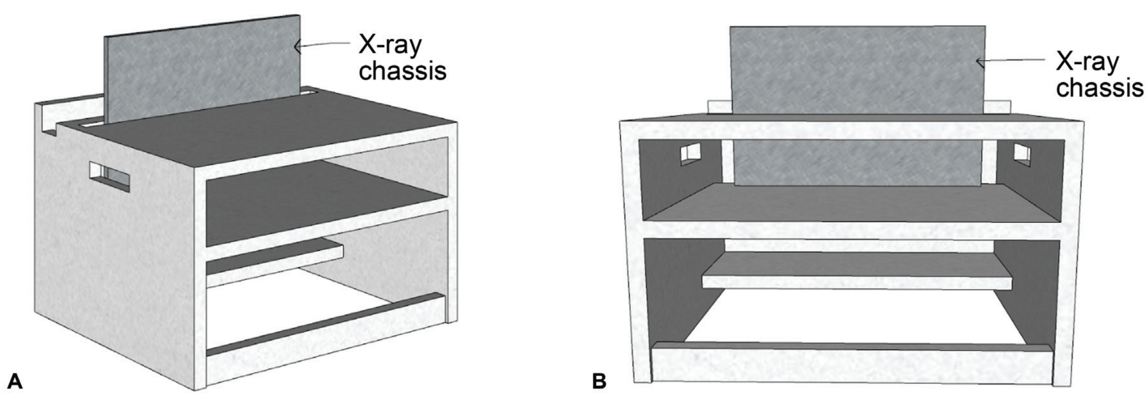

Fig. 4 Configuration for the profile view with the chassis perpendicular to the box.

Results

The evaluation of the radiographs using the Niza box was usually satisfactory, allowing the correct identification of the anatomical elements of the foot and ankle and angular reconstruction. Small variations in the images due to the feet' size are acceptable and expected, showing a categorical radiographic standardization.

►**Figs. 8**, **9** and **10** show images obtained at the AP, profile, and Saltzman views.

Discussion

Radiography is one of the diagnostic pillars in the propaedeutics of most orthopedic conditions.[3,11] Radiography closely relates to foot disorders in its wide range of indications, including different orthopedic conditions.[12] This study described and measured the radiographic AP, loaded profile, and Saltzman views of the foot. The goal of the loaded view is to use the mechanical variations proposed for the joints and anatomical elements.[13]

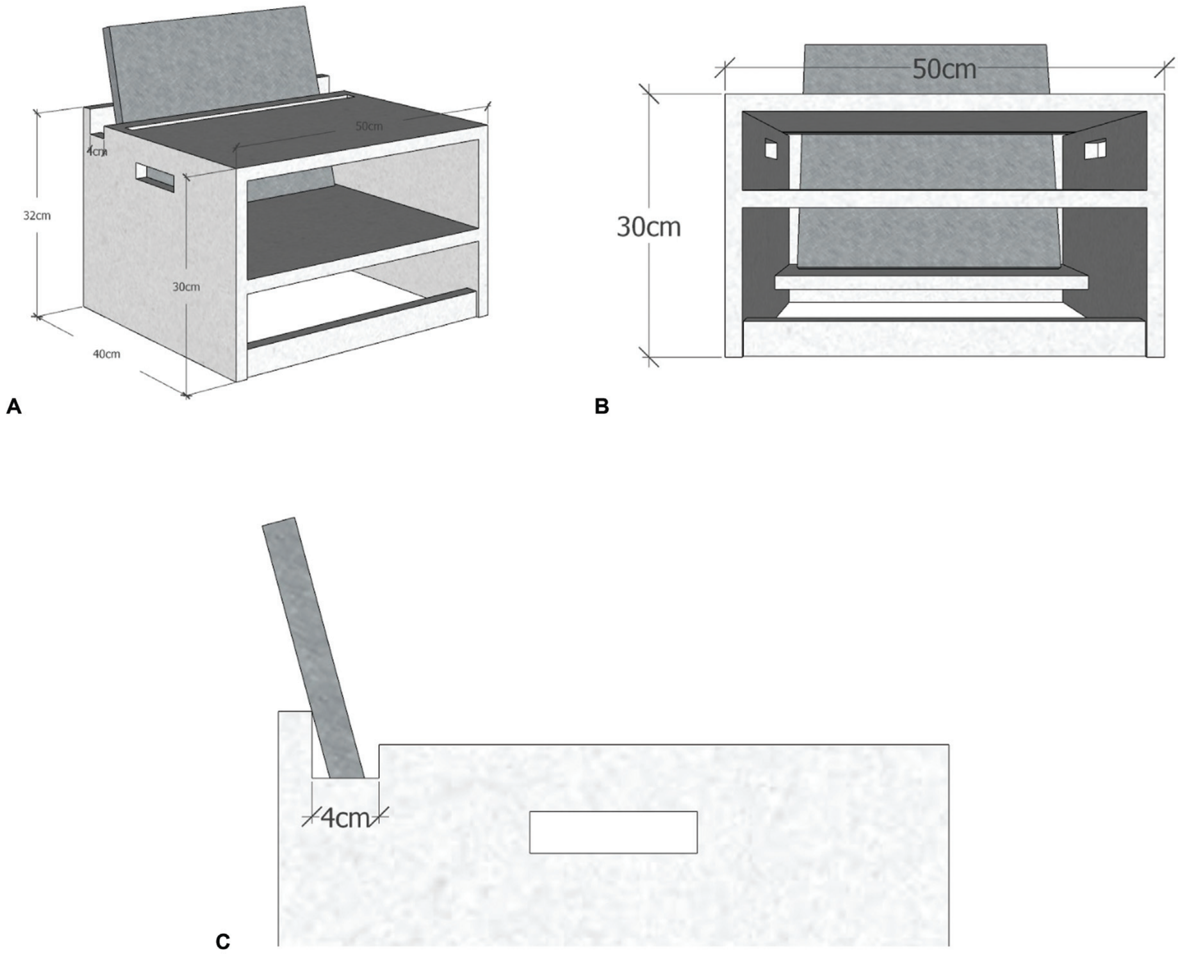

Fig. 6 Configuration for the Saltzman view with the chassis obliquely placed in a 20° angle.

Fig. 7 Correct positioning for the Saltzman view.

The Niza box has specific markings for foot positioning in radiographs. We introduced this method to standardize the final image. In orthopedic disorders requiring precise measurements of radiographic angles for treatment selection, technical errors in views can distort the results and disrupt the success of the treatment.[9]

Kuyucu et al.[14] studied the impact of incorrect radiographic positioning on the accuracy of measurements for hallux valgus considering the metatarsophalangeal and intermetatarsal angles. The authors concluded that positioning changes during foot radiography can lead to interpretation errors and modify the treatment. They even suggested that the metatarsophalangeal angle is more affected by foot positioning; as such, it is more acceptable to use the intermetatarsal angle as a parameter.[14]

Venning and Hardy compared pathological radiographs with a control group in the classic anatomical study of the human foot.[15] They showed three main reasons for errors in these examinations: errors in film marking and measuring; errors of a technical nature in the object, film, and radiographic source; errors resulting from foot variations, including weight distribution and the subjects' physical condition. This study measured angles in profile, mediolateral, and AP

Fig. 8 Anteroposterior radiograph using the Niza box.

Fig. 9 Profile radiograph using the Niza box.

Fig. 10 Saltzman radiograph using the Niza box.

views, concluding that the correct image evaluation required strict observation of the standard conditions.[15]

For foot conditions benefiting from radiographic examination, there are several techniques for hallux valgus correction, for instance, and it is known that many variables require consideration to guide the surgical treatment.[6] In the absence of an ideal technique for all cases, the accuracy of the diagnostic examination and then the angular measurement are paramount to facilitate the individualization and targeting of the proposed treatment.

Congenital clubfoot is a malformation presenting a wide spectrum of deformities, hindering the analysis of therapeutic outcomes.[16] Although different methods for result evaluation were proposed, several disagreements between them remain.[16] Radiography is a fundamental technique to provide the required information to improve knowledge and evaluation of the techniques used to treat this condition.[17]

Venning and Hardy established geometric values for each radiographic foot view. As such, regardless of the underlying condition, these measurements are reproducible. However, even though there is radiographic standardization, sources of variation are inherent to the process.[15]

Therefore, it is critical to understand the reasons for these variations to minimize technical errors in imaging. Different foot positioning may be one of the reasons for interpretive errors in the radiographic evaluation. This is why the authors created the Niza box as a single device to minimize differences in positioning and interpretation. The literature does not describe a similar device, highlighting the significance of this method for foot radiography.

Conclusion

Although the literary collection for radiography is vast, its standardization still varies according to the service, the training of the technical team, and the material used. Niza box is a good method to minimize interference and avoid errors in radiographic interpretation.

We conclude that rigorous standardization of the radiographic technique proposed using the Niza box device can offer advantages in terms of the quality and agility of the examination. The box allows the systematization of the radiographic process, reducing unnecessary repetitions and causing less exposure of the patient and the team to radiation.

In this sense, proposing the Niza box is innovative because it is a low-cost device made from recyclable material available in everyday life. It is a simple solution to a relevant problem in orthopedic evaluation.

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Conflict of Interests
The authors declare no conflict of interests.

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