ADVANCES IN THE USE OF MICROFOCUSED ULTRASOUND FOR FACIAL REJUVENATION

Abstract

The demand for non-invasive technologies to address facial rejuvenation and achieve a lifting effect has increased significantly over the past decades. Micro-focused ultrasound is a technology capable of inducing microthermal lesions at varying tissue depths, including the superficial musculoaponeurotic system (SMAS) and the dermis. Following the formation of these lesions, determined by power adjustment and the precise delivery of concentrated energy across different layers, a healing process is initiated, ultimately leading to SMAS contraction and dermal restoration, primarily associated with collagen synthesis. Accordingly, this study aimed to evaluate an application strategy utilizing micro-focused ultrasound on the facial region and to assess the outcomes resulting from this therapeutic approach. The findings demonstrated improved tissue support, particularly in the subocular region, temples, and nasolabial fold. Thus, it can be concluded that the use of micro-focused ultrasound on the facial region is a safe and effective therapeutic approach for treating skin aging, as it enhances tissue support and restores the tissue matrix, which also contributes to improved skin laxity.

Keywords: rejuvenation, ultrasound, skin regeneration, dermal matrix

INTRODUCTION

The skin aging process is multifactorial, affecting all skin layers and resulting in a significant degradation of collagen, a key structural component of the dermal matrix. The loss of intrinsic structural components results in the appearance of wrinkles and expression lines, often accompanied by local laxity, factors that directly impact the aesthetic appearance and overall quality of life of individuals. Notably, several other factors contribute to the onset and progression of this process, including hormonal influences, lifestyle habits, dietary behaviors, and external factors such as prolonged exposure to UVA and UVB radiation (1,2).

Currently, there is a growing preference for non-invasive techniques that achieve comparable rejuvenation effects while minimizing post-procedural downtime. As a result, continuous technological advancements are being developed to meet the increasing demand in this sector. Among the available technologies, micro-focused ultrasound has demonstrated remarkable progress in both development and clinical application (3–5).

This technology relies on the emission of ultrasound-generated mechanical waves that are precisely focused on specific points with high energy concentration, allowing for penetration at different depths. The technological design that enables this precision consists of a carefully engineered metallic structure with an exact concavity, ensuring the mechanical wave is directed to a single focal point with mathematically calibrated penetration depth. The treatment depth is determined by the targeted skin layers, utilizing spacers calibrated at 4.5 mm, 3.0 mm, and 1.5 mm to safely reach from the superficial musculoaponeurotic system (SMAS) down to the papillary dermis (6–12).

Due to the high-energy concentration delivered to a precise focal point, the resulting biological effect is thermal damage. Therefore, treatment protocols must account for the target area size and the number of pulses applied. Additionally, the quality of the treated tissue influences the outcome, as effective healing is essential to sustain the lifting effect observed immediately after treatment. The healing process associated with this type of lesion involves localized inflammation and biochemical signaling of factors responsible for cell differentiation and proliferation, with the most notable event being collagen synthesis, which contributes to the formation of a new tissue matrix (13,14).

Clinically, this treatment is advantageous as it is safe, effective, painless, and free from significant adverse effects, since only internal tissue layers are targeted, leaving the outer skin surface unaffected. However, despite extensive literature on the subject, gaps remain regarding the optimal application methodology.

Some strategies are based on linear application, dictated by the emission mode of certain devices, whereas advancements in modern applicators allow practitioners greater flexibility to align treatment with muscle fiber direction and the SMAS, thereby enhancing the lifting effect.

TECHNOLOGICAL EVOLUTION

Micro-focused ultrasound technology aims to emit targeted energy at single points capable of producing a thermal microlesion in the target tissue. Some equipment has an electronic form of emitting this energy, in lines, but requires cartridges that have a limited number of shots because the half-life of the crystal is compromised. This condition results in additional equipment costs that will result in added value in the therapeutic protocol. Currently, innovation in the development of micro-focused ultrasound equipment allows the production of this energy emission at no additional cost and without shot limits, in addition to preserving the half-life of the piezoelectric crystal that maintains the quality of the equipment for life, without the need for frequent replacements as presented by VISAGE® equipment, developed, and manufactured by the Brazilian Medical Equipment Industry – IBRAMED (Figure 1).

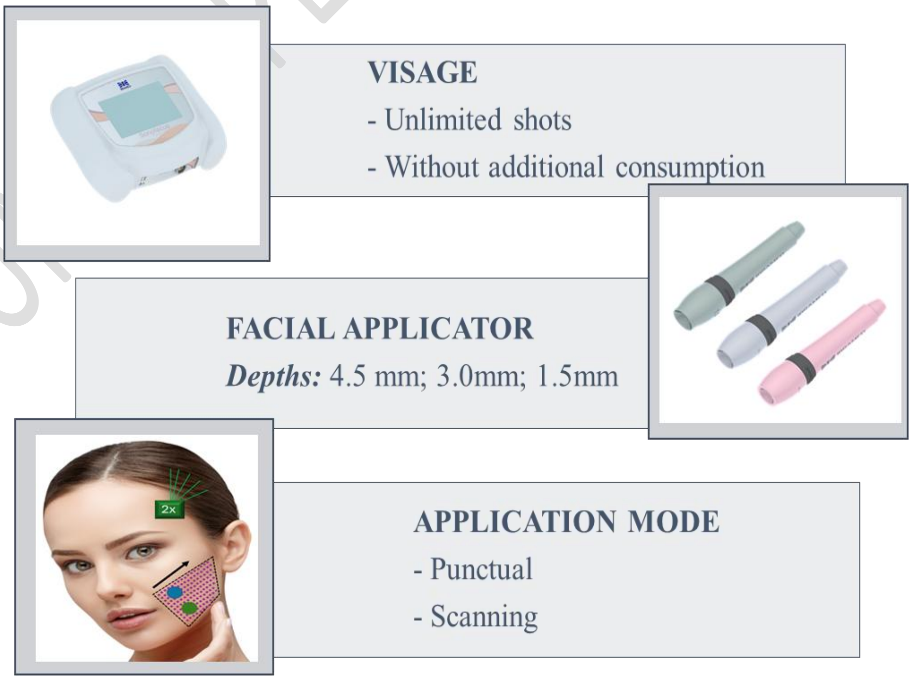

Figure 1 - Technological characteristics of VISAGE® equipment

With this equipment it is possible to achieve different depths in the target tissue. In the case of this study, was used three types of applications, with distance of 4.5, 3.0 and 1.5 mm, which can deliver the energy of interest, from the layer of the musculoaponeurotic system (SMAS) to the layer of the papillary and reticular dermis, considered more superficial (Figure 2). The emission of punctual energy, in this case, comes from a metal concavity present in the tip of the applicator, which allows the correct direction of this heat in the tissue layers, with the entire process only being possible due to precise mathematical calculations. In addition, the equipment offers therapeutic advantages through the possibility of different emission modes, punctual or scanning, associated with the therapist's freedom of choice for application in lines or even in circular movements, aiming in this case at tissue anchoring methods. With technological innovation and the autonomy of the professional regarding the application strategy, new and interesting therapeutic approaches emerge that benefit from microfocused ultrasound and expand to different areas that target facial treatment.

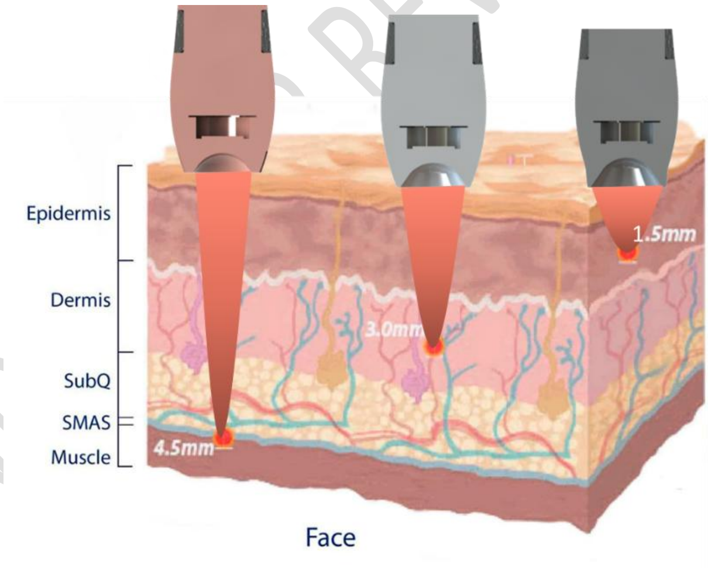

Figure 2 - Demonstration of the depth of action in the target tissue for each applicator

METHODOLOGY

Type and Location of Research

This case study was conducted at Casal da Beleza Clinic – Personalized Aesthetics in collaboration with the Research Group of Brazilian medical equipment industry – IBRAMED.

Clinical Protocol

The protocol application adhered to the safety guidelines provided by the manufacturer, considering the demarcated areas illustrated in Figures 1 and 2. Both application modes available in the equipment—point mode and scanning mode—were utilized for this protocol. Additionally, three spacers measuring 4.5 mm, 3.0 mm, and 1.5 mm were employed to target tissue layers ranging from the SMAS to the superficial dermis. As the protocol aimed to achieve a lifting effect followed by rejuvenation, the therapeutic strategy began with point mode application using 4.5 mm and 3.0 mm spacers on the midface region. This was followed by scanning mode application using all three spacers in the same area, as shown in Figure 1. The parameters used for this application are detailed in Figure 1. For treatment of the frontal and temporal regions, as illustrated in Figure 1, 4.5 mm and 3.0 mm spacers were used, always starting with the deeper one. Both point and scanning application modes were employed, following the previously described parameters. To complete the protocol, the 1.5 mm spacer was used in scanning mode exclusively on the midface region. Additionally, this 1.5 mm spacer was applied to other facial areas, as demonstrated in Figure 2, using the same energy settings but with reduced application time and number of pulses. It is important to highlight that Figure 2 provides a detailed representation of the appropriate treatment regions while also indicating risk areas.

4,5mm	3,0 – 3,4J	400/400	Pontual Scanning
3,5mm	2,6 – 5,0J	300/300	Pontual Scanning
1,5mm	5,0J	600	Scanning

Figure 3 - Areas and application modes considering the three target distances

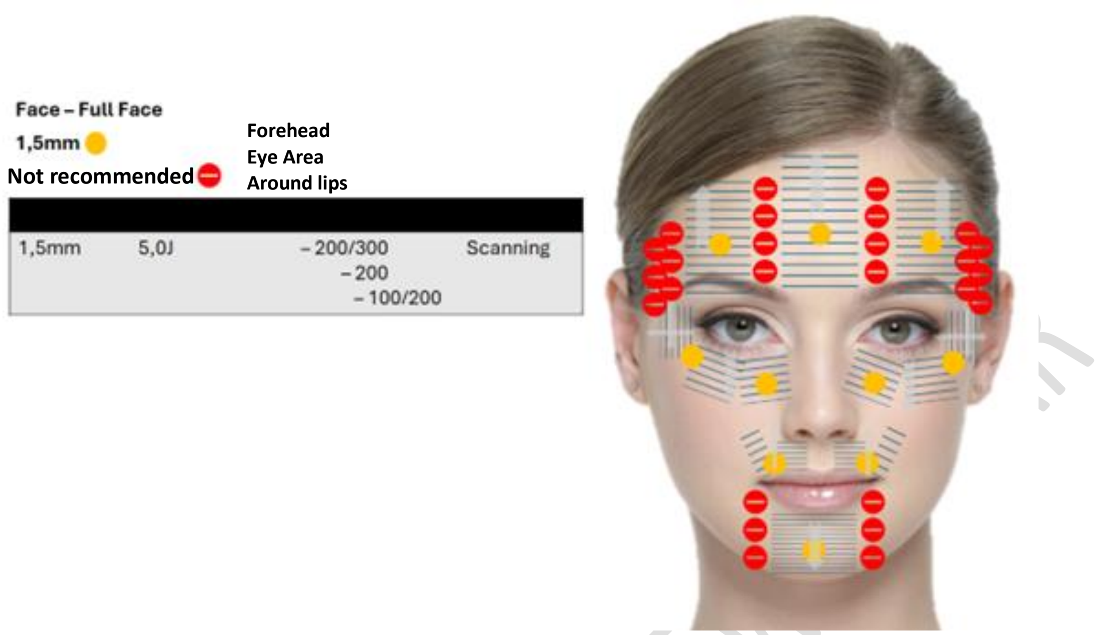

Figure 4 -Application areas considering only the surface layer

CLINICAL EVALUATION

Anamnesis of the Treatment Area

During evaluations, an anamnesis form designed specifically for this study will be completed. This form will include personal information, lifestyle habits, medications, observations related to the inspection of the treatment area, history of aesthetic procedures performed in the area, skin phototype, and a patient satisfaction questionnaire regarding the treated region.

Photographic Analysis

For photographic documentation, a digital camera will be used with the patient in an upright position. The assessment will focus on the central and lateral regions of the face in a neutral expression. The patient will maintain an upright posture, with their gaze aligned with the horizon and head centered in relation to the camera's positioning. The camera will be placed at 90 cm from the patient, with the zoom set to 1x.

Assessment of Skin Appearance

Improvement in the appearance of photoaged skin will be assessed using the GAIS (Global Aesthetic Improvement Scale), where: 0 = no improvement, 1

= slight improvement, 2 = moderate improvement, 3 = marked improvement, and 4 = significant improvement.

Patient Tolerance to Treatment

Pain perception in the treated area was evaluated using a subjective 0–10 visual analog scale, where: 0 = no pain or warmth, 1–4 = mild pain or warmth, 5–7 = moderate pain or warmth, and 8–10 = intense pain or warmth.

Patient Satisfaction Assessment

Participant satisfaction regarding treatment results and comfort in the treated area was assessed using a subjective 1–5 scale, where: 1 = very dissatisfied/very uncomfortable, 2 = dissatisfied/uncomfortable, 3 = no difference/no opinion, 4 = satisfied/comfortable, 5 = very satisfied/very comfortable (Noyman et al., 2021).

RESULTS

Photographic analysis demonstrated improvements in skin texture and quality. Overall, an increase in tissue support was observed, which resulted in a softening of the nasolabial fold and deep wrinkles in the forehead region. Additionally, a significant improvement was noted in the upper eyelid, likely due to treatment applied to the area between the frontal and temporal bones, extending into the scalp. Another area that benefited from this application was the upper eyelids and the fine wrinkles around the lateral eye region. Regarding tissue vitality, the entire face exhibited visible improvement, with particular emphasis on the midface and subocular regions, which clinically translated into a rejuvenated appearance and a reduction in laxity —commonly associated with a tired look.

Based on the skin improvement scale, as rated by an average of three blinded evaluators, the treatment outcome was classified as 3, indicating a marked improvement. For pain tolerance, assessed during the procedure, the patient rated their experience as 4, corresponding to mild pain and warmth. Thirty days post-treatment, the patient satisfaction scale was applied, yielding a score of 4, indicating overall satisfaction with the results.

DISCUSSION

Microfocused ultrasound technology has emerged as an effective alternative for restoring the dermal matrix, thereby addressing clinical concerns related to skin rejuvenation and laxity. Beyond these benefits, it offers a distinct advantage over other technologies due to its ability to target the Superficial Musculoaponeurotic System (SMAS), leading to significant tissue contraction that results in a lifting effect. Given these characteristics and its biological mechanism, thermal-induced coagulative microinjury, this technology is applicable to various body areas. These indications have been well-documented in scientific studies that confirm both its efficacy and safety (15–19). Despite the established effects, there remains no consensus regarding the optimal application methods. Some devices administer pulses electronically, allowing for application solely along linear patterns, whereas more versatile systems offer both point-by-point and scanning modes, with the method of application determined based on the desired clinical outcome. Thus, the objective of this study was to evaluate the effects of microfocused ultrasound using point-by-point and scanning application modes as part of a therapeutic strategy for treating age-related facial changes.

The results revealed notable improvements in facial tissue support. In the forehead and eyebrow regions, an observable lifting effect was achieved through structural reinforcement, contributing to an enhanced appearance of the eyelids and overall facial elevation. These aspects were evaluated and confirmed by Alam et al.,(20), which reported that after a single application of microfocused ultrasound to the forehead region, an elevation of up to 1.9 mm in the eyebrow area on both sides was observed in more than 83% of treated patients, with this effect being maintained for three months after the procedure.

Microfocused ultrasound energy possesses distinct properties that promote tissue support by replenishing the dermal matrix. This is directly linked to its ability to deliver targeted energy at varying depths. In the case of treatment in deeper layers, such as the SMAS, it becomes evident that the induced microinjury results in facial lifting, with a significant improvement in overall muscle support, which greatly enhances the appearance of the final outcome. At shallower depths, the treatment targets the papillary and reticular dermis, primarily stimulating dermal regeneration and collagen synthesis. This process not only reinforces tissue structure but also enhances skin elasticity, hydration, and overall vitality (21).

Technologies aimed at improving facial laxity and tissue support, such as lasers and radiofrequency, are well-established in the literature. However, due to the unique cellular mechanisms of microfocused ultrasound—which induce a robust tissue repair process leading to significant improvements in fine lines and skin laxity—this technology is gaining recognition as a non-invasive and painless alternative in aesthetic treatments (9,22).

The primary mechanism of action of microfocused ultrasound involves the precise and intense delivery of energy within a short duration (20–50 milliseconds), reaching various depths and effectively inducing thermal microinjuries in three key layers: the musculoaponeurotic layer, papillary dermis, and reticular dermis, at approximately 5 mm depth. Once these microlesions are established, the tissue repair process initiates, progressing through inflammation, proliferation, and remodeling phases, with the primary objective of dermal reconstruction via collagen synthesis. As it is a treatment that induces internal lesions, it has the advantage of not causing changes to the epidermis. Therefore, the patient does not require special care after the application, and no morphological changes, irritability, or erythema are visible in the superficial layer (9,20,22,23).

A study by Ko et al.(24) confirmed that microfocused ultrasound is safe and effective for enhancing facial elasticity and contouring. Park et al. concluded that microfocused ultrasound is a promising tool for addressing fine lines and skin laxity in the facial region of Asian patients, demonstrating, through an evaluation scale, a significant improvement three months after treatment, with its efficacy maintained for up to six months, particularly in the jowls, cheeks, and perioral area. Vachiramon et al. (15), evaluated the use of microfocused ultrasound for pore reduction in the facial region and found the technology to be effective, with high patient satisfaction. Friedman et al. (2) reported positive results in improving laxity in the submental and neck regions. However, the authors noted that achieving the desired clinical outcomes requires patients to present with only mild skin laxity. Regarding the longevity of the results (25), it is emphasized that this may be associated with the expression of the HSP47 protein, responsible for the quality of collagen crosslinking.

In a review conducted by Contini et al., the authors concluded that the technology is effective for treating clinical conditions classified as mild to moderate skin laxity, and that just one treatment session can result in long-term improvement. These findings align with the outcomes of the clinical case presented in this study, which demonstrated significant changes after one month of treatment. Considering the above, we conclude that microfocused ultrasound is effective in promoting facial rejuvenation, with notable improvement primarily in the subocular region, nasolabial folds, and temples, thereby enabling a therapeutic enhancement of facial contour in a painless and non-invasive manner.

REFERENCE

1. Zouboulis CC, Ganceviciene R, Liakou AI, Theodoridis A, Elewa R, Makrantonaki E. Aesthetic aspects of skin aging, prevention, and local treatment. Clin Dermatol [Internet]. 2019;37(4):365–72. Available from: https://doi.org/10.1016/j.clindermatol.2019.04.002
2. Friedman O. Changes associated with the aging face. Facial Plast Surg Clin North Am. 2005;13(3):371–80.
3. Jiang X, Savchenko O, Li Y, Qi S, Yang T, Zhang W, et al. A Review of Low-Intensity Pulsed Ultrasound for Therapeutic Applications. IEEE Trans Biomed Eng. 2019;66(10):2704–18.
4. Jones IT, Guiha I, Goldman MP, Wu DC. A randomized evaluator-blinded trial comparing subsurface monopolar radiofrequency with microfocused ultrasound for lifting and tightening of the neck. Dermatologic Surg. 2017;43(12):1441–7.
5. O'Brien WD. Ultrasound-biophysics mechanisms. Prog Biophys Mol Biol. 2007;93(1–3):212–55.
6. Alhaddad M, Wu DC, Bolton J, Wilson MJ, Jones IT, Boen M, et al. A Randomized, Split-Face, Evaluator-Blind Clinical Trial Comparing Monopolar Radiofrequency Versus Microfocused Ultrasound With Visualization for Lifting and Tightening of the Face and Upper Neck. Dermatologic Surg. 2019;45(1):131–9.
7. Contini M, Hollander MHJ, Vissink A, Schepers RH, Jansma J, Schortinghuis J. A Systematic Review of the Efficacy of Microfocused Ultrasound for Facial Skin Tightening. Int J Environ Res Public Health. 2023;20(2).
8. Friedman O, Isman G, Koren A, Shoshany H, Sprecher E, Artzi O. Intense focused ultrasound for neck and lower face skin tightening a prospective study. J Cosmet Dermatol. 2020;19(4):850–4.
9. Gliklich RE, White WM, Slayton MH, Barthe PG, Makin IRS. Clinical pilot study of intense ultrasound therapy to deep dermal facial skin and subcutaneous tissues. Arch Facial Plast Surg. 2007;9(2):88–95.
10. Suh DH, Shin MK, Lee SJ, Rho JH, Lee MH, Kim NI, et al. Intense focused ultrasound tightening in asian skin: Clinical and pathologic Results: Clinical. Dermatologic Surg. 2011;37(11):1595–602.
11. Kwack MH, Lee WJ. Efficacy of a home-used high-intensity focused ultrasound device on wrinkle reduction. Ski Res Technol. 2023;29(1):1–6.
12. Lee JC, Tsoi A, Kornfeld GD, Dawes IW. Cellular responses to. 2013;13(1978):618–34.
13. Robson MC. Growth factors as wound healing agents. Curr Opin Biotechnol.

1991;2(6):863–7.

14. Velnar T, Bailey T, Smrkolj V. The wound healing process: An overview of the cellular and molecular mechanisms. J Int Med Res. 2009;37(5):1528–42.

15. Vachiramon V, Namasondhi A, Anuntrangsee T, Kositkuljorn C, Jurairattanaporn N. A study of combined microfocused ultrasound and hyaluronic acid dermal filler in the treatment of enlarged facial pores in Asians. J Cosmet Dermatol. 2021;20(11):3467–74.

16. Vachiramon V, Triyangkulsri K, Iamsumang W, Chayavichitsilp P. Efficacy and Safety of Microfocused Ultrasound With Visualization in Abdominal Skin Laxity: A Randomized, Comparative Study. Lasers Surg Med. 2020;52(9):831–6.

17. Friedmann DP. Cryolipolysis for Noninvasive Contouring of the Periumbilical Abdomen with a Nonvacuum Conformable- Surface Applicator. Dermatologic Surg. 2019;45(9):1185–90.

18. Oni G, Hoxworth R, Teotia S, Brown S, Kenkel JM. Evaluation of a microfocused ultrasound system for improving skin laxity and tightening in the lower face. Aesthet Surg J. 2014;34(7):1099–110.

19. Kim Y, Yu H, An S, Ha D, Jung B. Handheld microfocused ultrasound device for facial lifting: A preliminary study of ULTIGHT. J Cosmet Dermatol. 2023;22(11):2982–8.

20. Alam M, White LE, Martin N, Witherspoon J, Yoo S, West DP. Ultrasound tightening of facial and neck skin: A rater-blinded prospective cohort study. J Am Acad Dermatol [Internet]. 2010;62(2):262–9. Available from: http://dx.doi.org/10.1016/j.jaad.2009.06.039

21. Ghassemi A, Prescher A, Riediger D, Axer H. Anatomy of the SMAS Revisited. Aesthetic Plast Surg. 2003;27(4):258–64.

22. White WM, Makin IRS, Barthe PG, Slayton MH, Gliklich RE. Selective creation of thermal injury zones in the superficial musculoaponeurotic system using intense ultrasound therapy: A new target for noninvasive facial rejuvenation. Arch Facial Plast Surg. 2007;9(1):22–9.

23. Laubach HJ, Makin IRS, Barthe PG, Slayton MH, Manstein D. Intense focused ultrasound: Evaluation of a new treatment modality for precise microcoagulation within the skin. Dermatologic Surg. 2008;34(5):727–34.

24. Ko EJ, Hong JY, Kwon TR, Choi EJ, Jang YJ, Choi SY, et al. Efficacy and safety of non-invasive body tightening with high-intensity focused ultrasound (HIFU). Ski Res Technol. 2017;23(4):558–62.

25. Hantash BM, Renton B, Laurence Berkowitz R, Stridde BC, Newman J. Pilot clinical study of a novel minimally invasive bipolar microneedle radiofrequency device. Lasers Surg Med. 2009;41(2):87–95.