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ORIGINAL ARTICLE

INSTRUMENTAL ASSESSMENT OF FACIAL SCAR TISSUE REMODELING: THE CAPABILITIES OF ULTRASOUND DERMOSONOGRAPHY AND THE POSAS SCALE

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Abstract

Assessment of scar tissue remodeling in the facial region is an essential component of reconstructive and aesthetic medicine because pathological scars may significantly affect appearance, tissue mobility, and psychosocial well-being. Modern diagnostic methods increasingly focus on objective evaluation of scar structure, vascularity, elasticity, and maturation dynamics. This study investigates the clinical significance of ultrasound dermosonography and the Patient and Observer Scar Assessment Scale (POSAS) in evaluating facial scar remodeling. Particular attention is given to structural changes within scar tissue, collagen organization, vascular characteristics, inflammatory activity, and functional skin properties during different stages of healing. The findings demonstrate that combined use of instrumental imaging and standardized clinical scales significantly improves diagnostic accuracy, monitoring of therapeutic response, and prediction of long-term scar outcomes. Ultrasound dermosonography provides detailed visualization of scar thickness, echogenicity, and tissue architecture, while POSAS allows comprehensive subjective and objective assessment of scar quality and patient satisfaction. Evaluation of facial scar remodeling is an essential component of reconstructive and aesthetic medicine because pathological scar changes may significantly affect facial appearance, tissue elasticity, functional mobility, and psychosocial well-being. Modern diagnostic approaches increasingly emphasize objective and reproducible methods capable of assessing structural and functional characteristics of scar tissue during different stages of healing. This study presents an expanded clinical analysis of the diagnostic capabilities of ultrasound dermosonography and the Patient and Observer Scar Assessment Scale in the evaluation of facial scar remodeling. Particular attention is given to the assessment of collagen organization, tissue thickness, vascular activity, inflammatory persistence, elasticity changes, and maturation dynamics in hypertrophic, atrophic, normotrophic, and keloid scars. The findings demonstrate that combined instrumental and clinical evaluation significantly improves diagnostic precision, allows accurate monitoring of therapeutic response, and enhances prediction of long-term aesthetic and functional outcomes. Ultrasound dermosonography provides detailed visualization of dermal architecture and fibrotic transformation, while POSAS offers comprehensive multidimensional assessment integrating both clinical observation and patient-reported symptoms.

Keywords: Facial scars, scar remodeling, ultrasound dermosonography, POSAS scale, hypertrophic scars, keloid, wound healing, reconstructive surgery, scar assessment, skin ultrasound

1. Introduction

Scar tissue remodeling is a prolonged biological process involving collagen reorganization, vascular stabilization, extracellular matrix remodeling, and gradual restoration of tissue elasticity following injury or surgical intervention. In facial tissues, scar maturation has particular clinical importance due to the aesthetic, functional, and psychological significance of the facial region. Pathological scars such as hypertrophic and keloid formations may lead to cosmetic deformity, restricted mobility, chronic discomfort, and emotional distress. Accurate evaluation of scar tissue characteristics is therefore essential for diagnosis, therapeutic planning, and long-term monitoring of treatment effectiveness. Traditional clinical examination alone may not provide sufficient information regarding internal scar structure, tissue density, vascular activity, or remodeling dynamics. Advances in noninvasive diagnostic technologies have significantly improved the ability to assess scar tissue objectively and quantitatively. Ultrasound dermosonography has emerged as a valuable imaging modality capable of visualizing scar thickness, echogenic patterns, collagen organization, vascular changes, and tissue heterogeneity in real time. Simultaneously, the Patient and Observer Scar Assessment Scale has become one of the most widely accepted clinical tools for standardized scar evaluation because it incorporates both physician-based assessment and patient-reported outcomes. Combining imaging technologies with validated clinical scales provides a more comprehensive understanding of scar remodeling processes and therapeutic response. Such integrated evaluation methods are especially important in facial reconstructive surgery, where even minor scar abnormalities may substantially influence aesthetic outcomes and quality of life. Scar remodeling is a prolonged biological process involving inflammatory regulation, angiogenesis, collagen reorganization, extracellular matrix remodeling, and gradual restoration of tissue integrity following trauma or surgical intervention. Under physiological conditions, these processes result in formation of flexible and cosmetically acceptable scar tissue. However, disturbances in healing dynamics may lead to pathological remodeling characterized by excessive fibrosis, abnormal collagen accumulation, vascular instability, tissue rigidity, and persistent inflammatory activity. Facial scars possess particular clinical significance because even minimal structural abnormalities may substantially influence facial symmetry, expression, psychological comfort, and social adaptation. Traditional clinical examination alone often provides limited information regarding internal scar architecture, tissue density, vascular changes, and subclinical inflammatory activity. Advances in noninvasive diagnostic technologies have significantly improved the ability to objectively assess scar maturation and monitor therapeutic effectiveness. Ultrasound dermosonography has become an increasingly valuable imaging modality due to its ability to visualize dermal thickness, echogenicity, collagen distribution, vascularity, and structural heterogeneity in real time without invasive intervention. Simultaneously, the Patient and Observer Scar Assessment Scale has gained widespread clinical acceptance as a standardized method for evaluating scar quality because it combines physician-based assessment with patient subjective perception regarding pain, itching, stiffness, pigmentation, and cosmetic appearance. Integration of instrumental imaging with standardized clinical scoring systems provides a more comprehensive understanding of scar remodeling processes and allows individualized therapeutic planning in reconstructive and aesthetic facial surgery.

2. Materials and Methods

This study was conducted using a retrospective clinical and instrumental analysis of patients presenting with postoperative or posttraumatic facial scars between 2020 and 2025. Patients with hypertrophic, atrophic, normotrophic, and keloid scars were included in the evaluation. Clinical examination was combined with ultrasound dermosonography and POSAS assessment to investigate scar remodeling characteristics during different healing stages. Ultrasonographic evaluation was performed using high-frequency dermal ultrasound equipment capable of assessing epidermal and dermal thickness, echogenicity, vascularity, collagen density, and tissue homogeneity. Scar thickness and structural changes were measured at standardized anatomical points within affected facial regions. POSAS evaluation included both observer and patient components assessing pigmentation, vascularity, thickness, relief, pliability, pain, itching, and overall cosmetic appearance. Additional clinical parameters included patient age, scar duration, anatomical localization, postoperative complications, inflammatory signs, and previous therapeutic interventions. Statistical analysis was conducted to determine correlations between ultrasonographic findings, POSAS scores, and clinical

characteristics of scar maturation.

3. Results

The analysis demonstrated that ultrasound dermosonography provided highly informative visualization of scar tissue architecture and remodeling dynamics in facial scars. Hypertrophic and keloid scars showed increased dermal thickness, heterogeneous echogenicity, elevated vascular activity, and irregular collagen distribution compared with normotrophic scars. Ultrasonographic findings revealed persistent inflammatory and fibrotic changes even in clinically mature scars, indicating prolonged remodeling activity beneath the skin surface. Atrophic scars demonstrated reduced tissue density and thinning of dermal structures with altered collagen organization. Strong correlation was identified between ultrasound findings and POSAS scores, particularly regarding scar thickness, pliability, pigmentation, and vascularity. Patients with higher POSAS scores generally exhibited greater ultrasonographic evidence of fibrosis, tissue heterogeneity, and vascular instability. Dynamic monitoring demonstrated gradual reduction in scar thickness and vascularity following therapeutic interventions including silicone therapy, corticosteroid administration, laser treatment, and regenerative procedures. Combined application of ultrasound dermosonography and POSAS significantly improved diagnostic precision and allowed objective monitoring of treatment effectiveness during long-term follow-up. Clinical and instrumental evaluation demonstrated that ultrasound dermosonography provided highly informative assessment of scar tissue structure and remodeling activity in different types of facial scars. Hypertrophic and keloid scars showed increased dermal thickness, irregular echogenicity, enhanced vascular signals, and heterogeneous collagen distribution compared with normotrophic scar tissue. Persistent subclinical inflammatory changes and fibrotic remodeling were frequently identified through ultrasound imaging even in scars appearing clinically mature during routine examination. Atrophic scars demonstrated reduced dermal density, tissue thinning, and disrupted collagen organization associated with decreased structural support and altered skin elasticity. Strong statistical correlation was observed between ultrasonographic parameters and POSAS scores, particularly regarding scar thickness, vascularity, pliability, pigmentation, and patient discomfort. Individuals with higher POSAS scores generally demonstrated greater structural abnormalities and vascular instability on ultrasound assessment. Longitudinal monitoring revealed progressive reduction in scar thickness, vascular activity, and tissue heterogeneity following therapeutic interventions including silicone-based treatment, corticosteroid therapy, laser procedures, and regenerative techniques. Combined use of ultrasound dermosonography and POSAS significantly improved evaluation of therapeutic effectiveness and allowed more accurate monitoring of scar maturation over time.

4. Discussion

The findings confirm that instrumental evaluation plays a critical role in understanding scar remodeling processes and optimizing management of pathological facial scars. Scar maturation involves complex structural and biochemical changes that may not be fully detectable through routine clinical examination alone. Ultrasound dermosonography provides detailed visualization of dermal architecture, collagen organization, vascular status, and inflammatory activity, allowing earlier identification of pathological remodeling tendencies. Increased scar thickness and altered echogenicity observed in hypertrophic and keloid scars reflect excessive collagen accumulation, persistent fibroblast activity, and prolonged tissue inflammation. The POSAS scale complements instrumental assessment by incorporating both objective clinical observation and subjective patient experience, thereby providing a multidimensional evaluation of scar quality. Integration of imaging techniques with standardized clinical scoring systems enhances diagnostic reliability and improves therapeutic decision-making. The ability to monitor structural changes during treatment also allows more accurate assessment of therapeutic effectiveness and long-term scar evolution. Contemporary reconstructive and aesthetic medicine increasingly emphasizes individualized scar management strategies guided by objective diagnostic parameters. Early identification of abnormal remodeling patterns through ultrasound assessment and POSAS monitoring may improve treatment timing and reduce progression of pathological fibrosis. Multidisciplinary collaboration among reconstructive surgeons, dermatologists, radiologists, and rehabilitation specialists remains essential for achieving optimal functional and cosmetic outcomes. The findings confirm the important role of combined

instrumental and clinical assessment in understanding scar remodeling dynamics and improving management of pathological facial scars. Scar maturation involves complex biological and structural changes that frequently remain undetectable through visual examination alone. Ultrasound dermosonography enables detailed evaluation of dermal architecture, collagen arrangement, tissue density, vascular activity, and inflammatory persistence, providing objective information regarding the internal condition of scar tissue. Increased scar thickness and heterogeneous echogenicity identified in hypertrophic and keloid scars reflect excessive collagen deposition, prolonged fibroblast activity, and chronic inflammatory stimulation. The POSAS system complements imaging findings by incorporating subjective patient experience and objective clinical evaluation into a standardized multidimensional scoring method. Integration of these diagnostic approaches enhances clinical accuracy and improves individualized therapeutic decision-making. Monitoring scar remodeling through repeated ultrasound and POSAS evaluation also allows earlier identification of pathological fibrosis progression and facilitates timely therapeutic intervention. Contemporary reconstructive and aesthetic medicine increasingly relies on objective quantitative assessment methods to optimize postoperative management and improve long-term cosmetic outcomes. Advances in high-frequency ultrasound technology, digital image analysis, and regenerative treatment strategies continue to expand possibilities for noninvasive scar evaluation and personalized rehabilitation. Effective management of pathological facial scars therefore requires coordinated multidisciplinary cooperation involving reconstructive surgeons, dermatologists, radiologists, rehabilitation specialists, and aesthetic medicine professionals.

5. Conclusion

Ultrasound dermosonography and the POSAS scale represent highly valuable complementary tools for comprehensive evaluation of facial scar tissue remodeling. Instrumental imaging provides objective assessment of scar structure, vascularity, collagen organization, and tissue thickness, while POSAS offers standardized clinical and patient-centered evaluation of scar quality and symptoms. Combined application of these methods significantly improves diagnostic accuracy, monitoring of therapeutic response, and prediction of long-term scar outcomes. Early identification of pathological remodeling processes allows timely therapeutic intervention and contributes to improved reconstructive and aesthetic results. Continued advancement of noninvasive diagnostic technologies and standardized assessment systems will further enhance clinical management of facial scars and optimize patient quality of life. Ultrasound dermosonography and the Patient and Observer Scar Assessment Scale represent highly effective complementary methods for comprehensive evaluation of facial scar remodeling. Instrumental imaging provides objective visualization of scar structure, vascularity, collagen organization, and tissue thickness, while POSAS allows standardized assessment of clinical appearance, symptoms, and patient satisfaction. Combined application of these diagnostic approaches significantly improves assessment accuracy, therapeutic monitoring, and prediction of long-term scar outcomes. Early identification of abnormal remodeling patterns allows timely intervention and contributes to improved reconstructive and aesthetic results. Continued development of noninvasive imaging technologies and standardized scar assessment systems remains essential for optimizing clinical management of facial scars and enhancing patient quality of life.

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