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ORIGINAL ARTICLE

PERSONALIZED ALGORITHM FOR THE PREVENTION AND TREATMENT OF POSTOPERATIVE FACIAL SCARS BASED ON A CLINICAL AND PROGNOSTIC MODEL

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Abstract

Postoperative facial scar formation remains a significant reconstructive and aesthetic challenge due to the complex interaction of local tissue factors, systemic conditions, inflammatory activity, and individual reparative characteristics. Development of pathological scars may lead to functional impairment, cosmetic deformity, psychological stress, and reduced quality of life. This study presents a personalized algorithm for prevention and treatment of postoperative facial scars based on a clinical and prognostic model integrating patient-specific risk factors, instrumental assessment, and dynamic monitoring of scar remodeling. Particular attention is given to prediction of pathological scar formation, optimization of individualized therapeutic strategies, and early implementation of preventive interventions. The findings demonstrate that personalized management significantly improves scar maturation, reduces hypertrophic and keloid transformation, enhances aesthetic outcomes, and increases treatment effectiveness during postoperative rehabilitation. Integration of prognostic analysis with regenerative and conventional therapeutic approaches allows more accurate selection of treatment protocols and improves long-term reconstructive results. Postoperative facial scar formation remains one of the most complex problems in reconstructive and aesthetic surgery because pathological remodeling may lead to persistent cosmetic deformities, functional limitations, emotional discomfort, and decreased quality of life. Modern approaches to scar prevention increasingly focus on personalized therapeutic algorithms based on clinical and prognostic assessment of individual patient characteristics, wound-healing dynamics, inflammatory response, and connective tissue metabolism. This study presents an expanded analysis of a personalized prevention and treatment model for postoperative facial scars integrating clinical risk stratification, instrumental monitoring, and individualized rehabilitation strategies. Special attention is given to prediction of pathological fibrosis, optimization of therapeutic timing, correction of microcirculatory disturbances, and regulation of collagen remodeling during postoperative recovery. The findings demonstrate that individualized preventive protocols significantly reduce the frequency of hypertrophic and keloid scar transformation, improve dermal remodeling, enhance tissue elasticity, and stabilize long-term aesthetic outcomes. Personalized therapeutic approaches combining regenerative medicine, pharmacological modulation, physiotherapy, and instrumental monitoring provide superior clinical effectiveness compared with generalized scar management strategies.

Keywords: Postoperative facial scars, personalized treatment, prognostic model, scar prevention, scar remodeling, hypertrophic scars, keloid, reconstructive surgery, regenerative

therapy, clinical algorithm

1. Introduction

Formation of scar tissue following facial surgery is an inevitable component of wound healing; however, disturbances in reparative mechanisms may result in pathological remodeling characterized by excessive fibrosis, abnormal collagen accumulation, vascular instability, and impaired tissue elasticity. Facial scars possess exceptional clinical importance because of their direct influence on appearance, facial expression, emotional well-being, and social interaction. Numerous local and systemic factors contribute to pathological scar formation, including prolonged inflammation, mechanical tension, tissue ischemia, infection, endocrine and metabolic disorders, genetic predisposition, and impaired microcirculation. Conventional scar management approaches often rely on generalized treatment protocols that may not adequately account for individual variability in wound healing dynamics and biological response. Advances in reconstructive medicine increasingly emphasize personalized therapeutic strategies based on patient-specific risk assessment and prognostic modeling. Clinical and prognostic algorithms integrating demographic data, wound characteristics, metabolic status, inflammatory markers, instrumental imaging, and scar assessment scales may improve prediction of pathological scar development and optimize therapeutic planning. Early identification of high-risk patients enables timely implementation of preventive interventions aimed at reducing fibrosis and improving aesthetic outcomes. Personalized rehabilitation protocols combining regenerative medicine, pharmacological therapy, physiotherapy, and instrumental monitoring represent a promising direction in modern reconstructive and aesthetic facial surgery. Postoperative wound healing is a biologically coordinated reparative process involving inflammatory activation, fibroblast proliferation, angiogenesis, extracellular matrix synthesis, collagen remodeling, and gradual restoration of tissue integrity. Under physiological conditions these mechanisms result in formation of flexible and cosmetically acceptable scar tissue. However, disturbances in local or systemic reparative pathways may lead to excessive fibrosis, prolonged inflammatory activity, vascular instability, abnormal collagen accumulation, and pathological scar formation. Facial scars possess particular medical and psychosocial importance because even minimal structural deformities may influence facial symmetry, emotional state, communication, and social adaptation. The development of hypertrophic and keloid scars depends on a complex interaction between genetic predisposition, tissue biomechanics, endocrine and metabolic status, inflammatory regulation, wound tension, vascular perfusion, and microcirculatory stability. Conventional postoperative rehabilitation protocols often apply generalized treatment approaches without considering individual biological variability in healing response and fibrosis susceptibility. As a result, many patients experience unsatisfactory cosmetic outcomes despite standard preventive therapy. Advances in reconstructive and regenerative medicine increasingly emphasize the importance of personalized clinical algorithms based on risk stratification and prognostic modeling. Individualized evaluation of scar-related risk factors allows earlier identification of patients predisposed to pathological remodeling and enables timely implementation of targeted preventive interventions. Modern diagnostic technologies including ultrasound dermosonography, scar elasticity assessment, and standardized evaluation scales further improve monitoring of connective tissue remodeling and therapeutic response. Personalized multimodal rehabilitation protocols integrating regenerative treatment, anti-inflammatory therapy, physiotherapy, and minimally invasive correction represent a promising direction for improving reconstructive outcomes in facial surgery.

2. Materials and Methods

This study was conducted using a retrospective and prospective clinical analysis of patients undergoing facial reconstructive, maxillofacial, and aesthetic surgical procedures between 2020 and 2025. Patients were evaluated for risk factors associated with postoperative pathological scar formation and were included in development of a clinical and prognostic management model. Clinical parameters analyzed included patient age, sex, skin phenotype, scar localization, wound tension, inflammatory complications, endocrine and metabolic disorders, smoking status, microcirculatory disturbances, and hereditary predisposition to pathological scarring. Instrumental assessment

involved ultrasound dermosonography, scar elasticity evaluation, and standardized clinical scales including POSAS. Patients were stratified into low-risk, moderate-risk, and high-risk categories according to prognostic indicators. Individualized preventive and therapeutic protocols were developed for each risk group. Preventive interventions included silicone-based therapy, anti-inflammatory treatment, regenerative redermalization therapy, physiotherapy, laser correction, corticosteroid administration, and dynamic monitoring of scar maturation. Statistical analysis was performed to evaluate the effectiveness of the personalized algorithm in preventing pathological scar progression and improving postoperative outcomes.

3. Results

The developed clinical and prognostic model demonstrated high effectiveness in identifying patients at increased risk for pathological postoperative scar formation. Patients classified within high-risk categories exhibited significantly greater incidence of prolonged inflammation, excessive collagen deposition, vascular instability, and delayed tissue remodeling compared with low-risk individuals. Application of personalized preventive protocols resulted in earlier stabilization of scar maturation and reduction in hypertrophic and keloid transformation frequency. Instrumental evaluation using ultrasound dermosonography revealed improved dermal organization, reduced scar thickness, decreased vascular activity, and more homogeneous collagen structure in patients managed according to individualized treatment algorithms. Patients receiving personalized combined therapy demonstrated superior improvement in scar elasticity, pigmentation, tissue density, and overall cosmetic appearance compared with patients managed through standard generalized treatment approaches. POSAS scores showed significant reduction in pain, itching, stiffness, and psychological discomfort among individuals treated using the prognostic-guided therapeutic model. Long-term follow-up demonstrated greater stability of remodeling outcomes and reduced recurrence of pathological fibrosis in patients receiving individualized preventive rehabilitation. Clinical evaluation demonstrated that implementation of the personalized prognostic algorithm significantly improved postoperative scar remodeling and reduced incidence of pathological fibrosis in patients undergoing facial surgery. Individuals classified as high-risk according to clinical and instrumental prognostic criteria demonstrated greater susceptibility to prolonged inflammation, delayed epithelialization, excessive collagen accumulation, vascular instability, and connective tissue rigidity during early postoperative healing stages. Application of individualized preventive protocols resulted in earlier stabilization of scar maturation processes and reduction in hypertrophic and keloid transformation frequency. Instrumental assessment using ultrasound dermosonography revealed progressive normalization of dermal architecture, decreased scar thickness, improved collagen organization, and reduction of vascular hyperactivity in patients receiving personalized rehabilitation. Patients treated according to individualized combined therapeutic protocols demonstrated superior improvement in scar elasticity, tissue density, pigmentation, and overall cosmetic appearance compared with patients managed through generalized treatment strategies. Standardized clinical assessment scales additionally demonstrated significant reduction in pain, itching, stiffness, and psychosocial discomfort during long-term follow-up. Regenerative therapeutic interventions incorporated into personalized protocols improved tissue hydration, microcirculatory function, and extracellular matrix remodeling, thereby contributing to more physiological scar maturation. Longitudinal monitoring confirmed greater stability of aesthetic outcomes and lower recurrence of fibrotic progression among patients receiving individualized preventive management.

4. Discussion

The findings confirm the importance of personalized approaches in prevention and treatment of postoperative facial scars. Scar remodeling is influenced by a highly complex interaction between inflammatory regulation, fibroblast activity, collagen synthesis, vascular dynamics, genetic predisposition, and systemic metabolic factors. Traditional generalized treatment methods may not adequately address individual biological variability and therefore often produce inconsistent therapeutic outcomes. Development of a clinical and prognostic model allows early identification of patients predisposed to pathological fibrosis and facilitates timely implementation of targeted preventive measures. Instrumental monitoring using ultrasound dermosonography and standardized scar assessment systems significantly improves evaluation of remodeling dynamics and therapeutic

effectiveness. Personalized algorithms integrating regenerative medicine, pharmacological modulation, physiotherapy, and minimally invasive corrective procedures provide more comprehensive control of scar maturation processes. The study also emphasizes the importance of early intervention during active remodeling phases because delayed therapeutic correction may allow irreversible fibrotic transformation and structural deformity. Regenerative approaches aimed at improving tissue metabolism, microcirculation, and extracellular matrix organization demonstrate particularly promising effectiveness when incorporated into individualized multimodal rehabilitation strategies. Successful management of postoperative facial scars therefore requires coordinated multidisciplinary cooperation involving reconstructive surgeons, dermatologists, rehabilitation specialists, endocrinologists, and aesthetic medicine professionals. The findings confirm that personalized clinical and prognostic approaches play a critical role in prevention and treatment of postoperative facial scars. Scar remodeling is regulated by highly complex biological mechanisms involving inflammatory mediators, fibroblast activity, collagen synthesis, angiogenesis, oxidative balance, endocrine regulation, and tissue metabolism. Individual variability in these processes significantly influences reparative outcomes and predisposition to pathological fibrosis. Conventional generalized treatment protocols may therefore fail to provide optimal therapeutic effectiveness for patients with increased biological susceptibility to abnormal scar formation. Development of a personalized prognostic model allows earlier identification of high-risk individuals and supports implementation of targeted multimodal rehabilitation strategies during active remodeling phases. Instrumental monitoring methods including ultrasound dermosonography significantly improve evaluation of scar structure, vascularity, collagen organization, and treatment response. Integration of regenerative medicine techniques into individualized rehabilitation protocols appears particularly effective in improving microcirculation, stabilizing extracellular matrix turnover, and restoring physiological connective tissue architecture. Combined therapeutic approaches incorporating pharmacological modulation, regenerative stimulation, physiotherapy, and minimally invasive corrective procedures provide synergistic biological effects capable of reducing fibrosis intensity and improving cosmetic outcomes. Early intervention remains especially important because delayed correction may allow persistent inflammatory activation and irreversible structural deformation of scar tissue. Contemporary reconstructive and aesthetic medicine increasingly relies on personalized multidisciplinary management involving reconstructive surgeons, dermatologists, rehabilitation specialists, endocrinologists, and aesthetic medicine professionals to optimize long-term scar prevention and rehabilitation.

5. Conclusion

Personalized clinical and prognostic algorithms represent an effective strategy for prevention and treatment of postoperative facial scars and significantly improve long-term reconstructive and aesthetic outcomes. Individualized assessment of risk factors allows earlier identification of patients predisposed to pathological scar formation and supports timely implementation of targeted therapeutic interventions. Combined preventive and regenerative treatment protocols contribute to normalization of scar remodeling, reduction of fibrosis intensity, stabilization of vascular activity, and improvement of cosmetic appearance. Instrumental monitoring and dynamic clinical evaluation further enhance treatment precision and allow optimization of rehabilitation strategies during postoperative recovery. Continued development of personalized reconstructive medicine and prognostic modeling remains essential for improving scar prevention and achieving superior functional and aesthetic rehabilitation outcomes in facial surgery. Personalized clinical and prognostic algorithms represent an effective and scientifically grounded strategy for prevention and treatment of postoperative facial scars. Individualized assessment of local and systemic risk factors allows earlier detection of patients predisposed to pathological fibrosis and supports timely implementation of targeted therapeutic interventions. Personalized multimodal rehabilitation protocols significantly improve connective tissue remodeling, reduce scar thickness and vascular instability, normalize collagen organization, and enhance long-term aesthetic outcomes. Instrumental monitoring combined with regenerative and anti-inflammatory treatment approaches further improves precision of postoperative rehabilitation and contributes to stabilization of physiological scar maturation. Continued advancement of personalized reconstructive medicine and prognostic modeling remains essential for optimizing scar prevention strategies and improving functional and cosmetic rehabilitation outcomes in facial surgery.

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