Quantification of Erythema Associated With Varying Suture Materials in Facial Surgery Repair: A Randomized Prospective Study

Ali Majd, MD,*† Catherine Lim, BKin, MD,* and David Zloty, MD, FRCPC*†

BACKGROUND A common concern among patients following Mohs micrographic surgery (MMS) is scar appearance and residual erythema. However, few studies have quantitatively compared scar erythema between different suture materials.

OBJECTIVE To quantify erythema intensity (EI) associated with use of percutaneous nylon, irradiated polyglactin-910 (IPG) and fast-absorbing gut (FG) sutures on facial sites.

METHODS After undergoing MMS, 210 patients were randomized to one of 2 groups. Patients in the first group ($n = 105$) had their defects repaired half with continuous IPG sutures and the other half with nylon sutures; the second group ($n = 105$) received IPG and FG sutures. Standardized photographs of scars were taken at 1 week, 2 months, and 6 months postoperatively and computer-assisted image analysis was used to quantify EI.

RESULTS The average EI was comparable between all 3 suture materials at 1 week, 2 months, and 6 months. From 1 week to 2 months, EI in nylon, IPG, and FG sutures decreased by 24.8%, 12.8%, and 17.9% ($p < .05$), respectively. There was no statistically significant difference in EI among suture types between 2 and 6 months.

CONCLUSION Erythema decreased significantly during early scar maturation in all groups and was comparable between all suture materials at 1 week, 2 months, and 6 months.

Surgical excision is the preferred management for most nonmelanoma skin cancers (NMSC) of the face.[1,2] Given the aesthetic importance of the face, patients are often concerned about scar cosmesis post-operatively, including residual erythema, with many patients seeking treatment to reduce scar redness.[2–4]

Erythema has classically been believed to be greater with braided absorbable sutures (irradiated polyglactin-910 [IPG]), or sutures undergoing proteolysis (fast-absorbing gut [FG]), compared with perceived inert materials such as nylon. As a result, IPG or FG sutures have historically been less commonly used for epidermal closure of the face.[4] More recent studies suggest there is no significant difference in erythema between nonabsorbable and absorbable sutures.[4–7] However, studies assessing scar outcomes and erythema have lacked an objective measurement and comparison of erythema. We have devised a randomized, prospective, split-scar trial to objectively compare erythema intensity (EI) and evolution of erythema over 6 months, using nylon, IPG and FG sutures for facial epidermal closure.

*From the *Faculty of Medicine, University of British Columbia, Vancouver, British Columbia, Canada; †Department of Dermatology and Skin Science, University of British Columbia, Vancouver, British Columbia, Canada*

The authors have indicated no significant interest with commercial supporters.

Institution of research: Department of Dermatology and Skin Science, University of British Columbia, Vancouver, British Columbia, Canada.

Name of institution and department where work was performed: Department of Dermatology and Skin Science, University of British Columbia, Vancouver, British Columbia, Canada.

Ethics Approval: The investigation received full approval by the Clinical Research Ethics Board of the University of British Columbia (study ID: H14-02604 & H13-01961).

Address correspondence and reprint requests to: David Zloty, MD, FRCPC, 835 W 10th Avenue, Vancouver, British Columbia V5Z 4E8, Canada, or e-mail: david.zloty@vch.ca

http://dx.doi.org/10.1097/DSS.0000000000003625

Methods

Recruitment and Study Population

The study population comprised patients continuously enrolled from October 2013 to June 2017 from the Dermatologic Surgery Centre within the Department of Dermatology and Skin Science at the University of British Columbia. The patients were previously enrolled in trials to study suturing method and suture material on facial scar outcome using scar assessment scales. Ethics approval (H13-01961 and H14-02604) was obtained from the University of British Columbia Research Ethics Board before study commencement. The supporting trials were registered with Clinicaltrials.gov (NTC0193259 and NTC02334917).

Study Design

This randomized prospective split-scar study compared the EI associated with nylon, IPG, and FG sutures and its evolution over time. These 3 suture materials were compared with each other through 2 previously-conducted parallel randomized trials which compared IPG versus FG, and IPG versus nylon. Patients were eligible for inclusion if they were 18 years or older, with a surgery defect on the face requiring a wound repair of at least 4 cm in length. Patients were excluded if they had a history of keloid formation or previous radiation to the wound area.

Randomization to determine which half of the wound would be sutured with the varying suture materials was completed for 210 patients before study initiation using a randomization list generated from a web service (http://www.randomization.com). Participants underwent Mohs micrographic surgery (MMS) in standard fashion. All Mohs defects were completely closed without tension using buried 4-0 or 5-0 polyglactin 910 (Vicryl, Ethicon, Somerville, NJ). Epidermal running sutures of nylon (Ethilon, Ethicon) on a P-3 needle, or FG (Ethicon) on a PC-1 needle, were placed along half of the wound, with IPG (Vicryl Rapide, Ethicon) on a P-3 needle placed on the other half. Sutures were spaced approximately 3 to 4 mm apart, 2 to 3 mm from the wound edge, with closing tension just sufficient to allow complete wound edge apposition. The split-scar suture material orientation and erythema evolution are demonstrated in Figure 1. Standard postoperative care with petroleum jelly followed. The nylon suture was removed at the 1-week postoperative visit. The IPG and FG sutures were left in place.

Close-up photographs of the scars were taken using preset aperture (14), shutter speed (1/60 seconds), and flash settings (+1/3 exposure compensation) on a CanonEOS Digital RebelXT, CanonMR-14EXringflash, and Canon-EFS 60 mm f/2.8 macrolens. Photographs were taken 1 week, 2 months, and 6 months postoperatively in the same follow-up room under closely matched lighting parameters and camera angles. The photographs were then assessed using computer-assisted image processing at the 1 week, 2 months, and 6 months postoperative intervals to quantify the EI in each half of the scars. Computer-assisted image-processing was performed using MATLAB software (MATLAB R2017a; The MathWorks, Inc., Natick, MA) on both sides of each scar, and on closely situated, but not involved, skin. The normal skin was used to determine each patient's baseline skin color according to the RGB color space, and scar erythema was quantified and compared with baseline skin color at each time interval. This technique was validated clinically in a previous study that used a very similar methodology.[8]

Although the mathematical computation of color space differences is beyond the scope of this clinical manuscript, it should be noted that EI is determined by calculating the Delta E metric. The RGB values of the patient's baseline skin color are determined, as are those of the area of erythema. These values are then converted to the L*a*b color space, and inserted into the Delta E equation to calculate the color difference. Further information regarding Delta E computation and validation for color analysis and comparison can be found in the literature.[8–12]

Statistical Analysis

Statistical analysis was performed with SPSS V22. Paired *t*-tests were used to compare average postoperative EI at different time intervals between the 3 suture materials. All statistical analyses were performed with MATLAB software, similar to our group's previous study.[8] To determine an appropriate sample size, power calculations were performed before study enrollment. To allow for the detection of a clinically relevant difference of >1 interval in EI (moderate effect size of 0.5) with a power of 80% and a significance level of 5% (2 tailed), a total of 65 patients was required. However, 210 patients were recruited to allow for more precise intracohort analysis of EI over time for each suturing technique. Paired *t*-tests were used for comparison of average EI values at different time intervals between nylon, IPG, and FG.

Results

In total, 210 patients were randomized. Patient demographic and operative data are listed in Table 1. At 1 week, the initial calculation of average EI for nylon was statistically and clinically greater than the average EI of IPG and FG (for both, $p < .05$). However, the photographs of the patients in the nylon cohort at 1 week were taken immediately after suture removal, raising the possibility of suture removal-induced erythema as a confounding factor. A small proof of concept study consisting of 12 patients was completed using the same MATLAB-based methodology to quantify erythema before and immediately after removal of nylon sutures to further investigate this possibility. This proof-of-concept study did in fact demonstrate transiently increased erythema immediately after suture removal, which corresponded to a 9.3% ($p < .001$) increase in mean EI in comparison to presuture removal erythema. Consequently, the 1-week EI values for nylon were reduced by 9.3%, and the corrected values were used in the final study analysis.

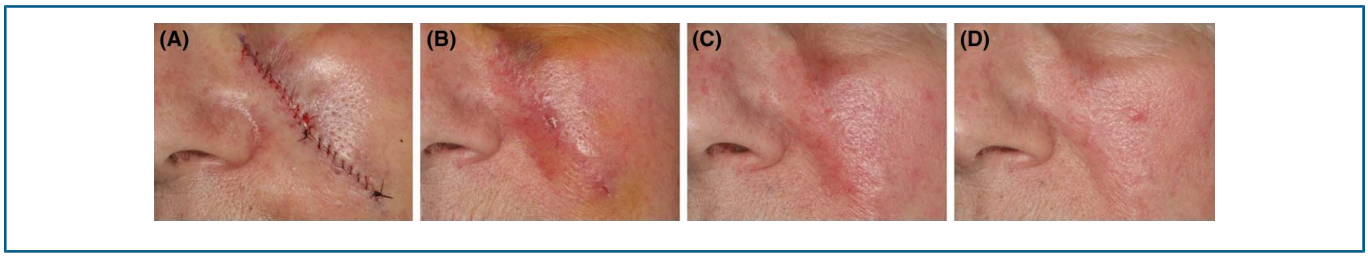

Figure 1. Evolution of erythema. A study participant who was randomized to have IPG superiorly and nylon inferiorly on the left cheek is demonstrated. Images are from immediately postoperation (A), followed by 1 week (B), 2 months (C), and 6 months (D), postoperatively. There are comparable intensities of erythema in the IPG and nylon halves of the scar in all 4 time intervals. IPG, irradiated polyglactin-910.

TABLE 1. Patient Demographics		
	Nylon Versus IPG (n = 105)	**IPG Versus FG (n = 105)**
Sex, % (n)		
Men	51 (54)	62 (65)
Women	49 (51)	38 (40)
Mean age, range	70.6, 36–93	69.2, 45–95
Phototype, % (n)		
I	21 (22)	23 (24)
II	48 (50)	64 (67)
III	31 (32)	11 (12)
IV	1 (1)	2 (2)
Diagnosis, % (n)		
BCC	79 (83)	80 (84)
SCC	17 (18)	15 (16)
SCCIS	1 (1)	1 (1)
LM/LMM	3 (3)	4 (4)
Anatomic unit, % (n)		
Nose	36 (38)	41 (43)
Cheek	32 (34)	35 (37)
Forehead	25 (26)	19 (20)
Lip	7 (7)	5 (5)
Repair type, % (n)		
Side to side	51 (52)	30 (32)
Flaps	49 (49)	70 (73)
Location of IPG, % (n)		
Superior/medial	49 (51)	50 (52)
Inferior/lateral	51 (54)	50 (53)

IPG, irradiated polyglactin 910; FG, fast-absorbing gut.

There was no statistically significant difference in mean EI between nylon, IPG, and FG sutures at 1 week, 2 months, or at 6 months ($p > .05$ for all suture; Table 2). From 1 week to 2 months, there was a statistically significant decrease in EI for all sutures: nylon showed a 24.8% decrease in EI ($p < .0001$); IPG showed a 12.8% decrease in EI ($p < .05$); and FG showed a 17.9% decrease in EI ($p < .05$). The change in EI from 2 to 6 months was not statistically significant in any group ($p > .05$ for all sutures; Figure 2).

The EI of the scar never returned to zero, or baseline skin color, even at the conclusion of our study, indicating that scar erythema persisted at 6 months.

Discussion

Current methods of assessment of scar cosmesis and erythema, a key component of patient satisfaction and dermatologic quality of life (QOL) scales, can be criticized as being subjective and qualitative.[13,14] To our knowledge, this is the first study that has quantitatively assessed EI in facial surgery scars as related to suture material.

We devised a randomized, prospective, split-scar trial where patients serve as their own control. Standardized photographs, combined with computer-assisted MATLAB software-based image processing, allowed us to calculate and compare each patients' unique average baseline skin erythema to the average erythema in each half of their scar. The quantitative difference in erythema between baseline skin, and each half of the scar, is captured by EI. This metric could then be compared across different subjects, repair types, and facial locations. Colorimetry has also been used to measure erythema objectively. However, there is significant interrater variability, and colorimetry can only measure one small area at a time.[15] Our data suggest that no one suture type (nylon, IPG, or FG) is superior with respect to long-term erythema (Table 2 and Figure 2). Quantitative analysis of EI related to facial surgery scars showed no statistically significant difference between average EI associated with the different suture materials at 1 week, 2 months, or 6 months. This is contrary to established dogma where inert single-strand sutures, such as nylon, are purported to be less inflammatory, and thus develop less erythema when compared with multi-strand sutures, such as IPG. In addition, absorbable sutures, which are broken down through hydrolysis (IPG) or proteolysis (FG), are also believed to induce more inflammation and erythema than inert single-strand sutures. Our study's quantitative findings, together with previous qualitative data,

TABLE 2. Average EI in Nylon, IPG, and FG at 1 Week, 2 Months, and 6 Months

	Suture Material			*p* at Each Time Interval		
	Nylon	IPG	FG	Nylon Versus IPG	Nylon Versus FG	IPG Versus FG
Mean EI at each time interval (SD)						
1 wk	14.27 (6.34)	12.43 (5.79)	13.08 (6.01)	0.083	0.096	0.45
2 mo	10.72 (5.12)	10.84 (4.95)	10.75 (4.79)	0.88	0.97	0.91
6 mo	10.91 (5.95)	10.58 (6.10)	10.57 (4.93)	0.70	0.67	0.99
p values for each suture material						
1 wk vs 2 mo	**<0.0001**	**0.049**	**0.0041**			
2 wk vs 6 mo	0.81	0.76	0.81			
1 wk vs 6 mo	**<0.0001**	**0.035**	**0.0024**			

Comparison of the average percent change in EI for Nylon, IPG, and FG at 1 PG between 1 week, 2 months, and 6 months. *p* values yielded from pair-wise comparisons of EI values for each time interval, and for each suture material are included. Statistically significant *p* values are bolded.
IPG, irradiated polyglactin-910; FG, fast-absorbing gut.

support the conclusion that absorbable sutures can be used to maximize patient convenience and cost efficiency without compromising long-term scar erythema.[16,17]

Our study also informs patients and clinicians of the trajectory of scar evolution and healing after facial MMS. The rate of EI regression was greatest over the first 2 months postoperatively for all 3 suture materials and its rate diminished substantially thereafter, suggesting most erythema regression occurs early in the healing process.

Quality of life is an essential consideration in the treatment outcomes of cutaneous NMSC given its low mortality rate.[1,13] Scar cosmesis contributes to QOL and has implications on mental health and function.[2] The information on scar erythema drawn from our study can help counsel patients, manage their expectations, and therefore improve QOL perioperatively.[2,13]

In the future, there may be clinical utility and feasibility of computer-assisted image processing to quantify and track skin erythema over time in other dermatologic conditions, such as rosacea.[18] In addition, this technology may be used alongside tele-dermatology to quantitatively assess photos submitted by patients.[19] It also overcomes the problem of low video resolution, color misrepresentation, and inappropriate saturation that are often encountered during video-conferencing and may assist in evaluating surgical scars and wound healing in lieu of an in-person visit.

Although this study has value by providing objective evidence of scar erythema, there are some limitations. Our data were taken from a single institution whose patients consisted primarily of elderly white individuals with facial wounds (the average age was 70 years and phototypes I to III). This limits the generalizability of results to those of different skin types, age, and surgical sites. For example, elderly and lighter skin typically heal with less scarring compared with younger or darker skin.[20] A multi-institutional study would provide a more diverse population and different anatomical locations to represent other

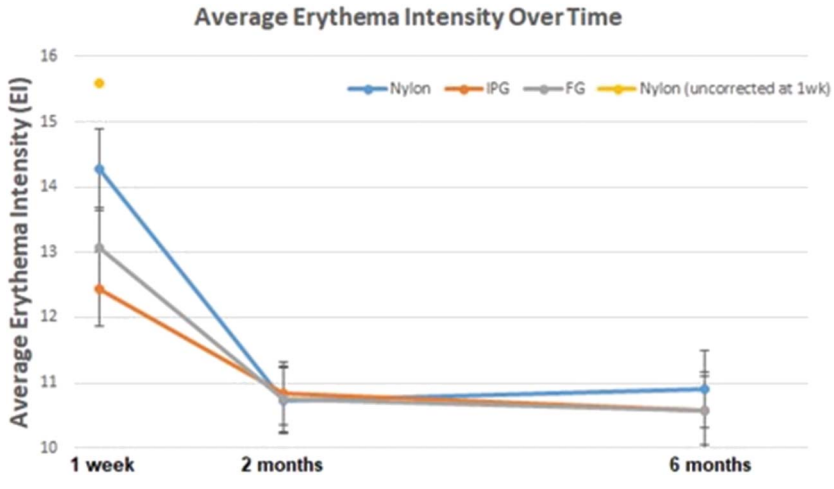

Figure 2. Erythema intensity over time. Photographs of the scar were taken at 1 week, 2 months, and 6 months. In the nylon group, sutures were removed before taking photos. As such, EI for nylon sutures at 1 week was corrected according to the results of the proof-of-concept study. The uncorrected EI for nylon sutures at 1 week is also shown. EI, erythema intensity.

clinical scenarios and could account for differing surgical techniques and skills.

In addition, the use of different types of flaps in some repairs in our study may have resulted in varying degrees of tension along the incision lines in comparison to linear repairs. This could have influenced the intensity of erythema between the 2 halves of the scar in the same patient, and between different patients with the same suture material. The large randomized patient number should mitigate any differences attributable to this variable.

Another limitation of our study is that photographs were taken after suture removal in patients who had nylon sutures at 1 week postoperatively. As such, a correction was performed using the results of our proof-of-concept study. After this correction, it was determined none of the 3 suture materials resulted in statistically significantly greater mean EI than the others. A future study could further investigate erythema evolution in association with nylon and absorbable sutures on the face specifically at 1 week postoperatively.

Conclusion

This study provides objective evidence to support that there is no statistically significant difference in erythema between nylon, IPG, and FG after facial MMS. This study can inform physicians' selection of suture material and manage patient expectations after facial MMS.

References

1. Witmanowski H, Lewandowska M, Szychta P, Sporny S, et al. The development of squamous cell carcinoma in a patient after kidney transplantation: a case report. *Postępy Dermatologii i Alergologii* 2013;30:65–71.
2. Lukowiak TM, Perz AM, Veerabagu SA, Lee MP, et al. Patient quality of life after interpolated flap repair of nasal mohs surgery defects: a multicenter prospective cohort study. *JAMA Dermatol* 2021;157: 1213–6.
3. Sobanko JF, Sarwer DB, Zvargulis Z, Miller CJ. Importance of physical appearance in patients with skin cancer. *Dermatol Surg* 2015; 41:183–8.
4. Gillanders SL, Anderson S, Mellon L, Heskin L. A systematic review and meta-analysis: do absorbable or non-absorbable suture materials differ in cosmetic outcomes in patients requiring primary closure of facial wounds? *J Plast Reconstr Aesthet Surg* 2018;71:1682–92.
5. Bond JS, Duncan JAL, Mason T, Sattar A, et al. Scar redness in humans: how long does it persist after incisional and excisional wounding? *Plast Reconstr Surg* 2008;121:487–96.
6. Keaney TC, Tanzi E, Alster T. Comparison of 532 nm potassium titanyl phosphate laser and 595 nm pulsed dye laser in the treatment of erythematous surgical scars: a randomized, controlled, open-label study. *Dermatol Surg* 2016;42:70–6.
7. Moran B, Humphrey S, Seal A, Berkowitz J, et al. Photographic assessment of postsurgical facial scars epidermally sutured with rapidly absorbable polyglactin 910 or nylon: a randomized clinical trial. *J Am Acad Dermatol* 2020;83:1395–9.
8. Majd A, Akbari A, Zloty D. Quantification of erythema associated with continuous versus interrupted nylon sutures in facial surgery repair: a randomized prospective study. *Dermatol Surg* 2020;46: 757–62.
9. Kim JG, Yu B, Lee YK. Correlations between color differences based on three color-difference formulas using dental shade guide tabs. *J Prosthodont* 2009;18:135–40.
10. Choi KW, Kim KH, Kim YH. Comparative study of the gross interpretation of phototesting and objective measurement with using a spectrophotometer for patients with psoriasis and vitiligo treated with narrow-band uvb. *Ann Dermatol* 2009;21:136–41.
11. Miller SA, Coelho SG, Zmudzka BZ, Bushar HF, et al. Dynamics of pigmentation induction by repeated ultraviolet exposures: dose, dose interval and ultraviolet spectrum dependence. *Br J Dermatol* 2008; 159:921–30.
12. Behrangi E, Shemshadi M, Ghassemi M, Goodarzi A, et al. Comparison of efficacy and safety of tranexamic acid mesotherapy versus oral tranexamic acid in patients with melasma undergoing Q-switched fractional 1064-nm Nd:YAG laser: a blinded RCT and follow-up. *J Cosmet Dermatol* 2022;21:279–89.
13. Zhang J, Miller CJ, O'Malley V, Etzkorn JR, et al. Patient quality of life fluctuates before and after Mohs micrographic surgery: a longitudinal assessment of the patient experience. *J Am Acad Dermatol* 2018;78:1060–7.
14. Chae JK, Kim JH, Kim EJ, Park K. Values of a patient and observer scar assessment scale to evaluate the facial skin graft scar. *Ann Dermatol* 2016;28:615–23.
15. Ly BCK, Dyer EB, Feig JL, Chien AL, et al. Research techniques made simple: cutaneous colorimetry: a reliable technique for objective skin color measurement. *J Invest Dermatol* 2020;140:3–12.e1.
16. Luck R, Tredway T, Gerard J, Eyal D, et al. Comparison of cosmetic outcomes of absorbable versus nonabsorbable sutures in pediatric facial lacerations. *Pediatr Emerg Care* 2013;29:691–5.
17. Xu B, Xu B, Wang L, Chen C, et al. Absorbable versus nonabsorbable sutures for skin closure: a meta-analysis of randomized controlled trials. *Ann Plast Surg* 2016;76:598–606.
18. Foolad N, Prakash N, Shi VY, Kamangar F, et al. The use of facial modeling and analysis to objectively quantify facial redness. *J Cosmet Dermatol* 2016;15:43–8.
19. Kantor J. Reliability and photographic equivalency of the scar cosmesis assessment and rating (SCAR) Scale, an outcome measure for postoperative scars. *JAMA Dermatol* 2017;153:55–60.
20. Visscher MO, Bailey JK, Hom DB. Scar treatment variations by skin type. *Facial Plast Surg Clin North Am* 2014;22:453–62.