Archives of Plastic Surgery APS

COMMUNICATION

The Optimal Color of Background Sheets for Microsurgery

Tomoki Kiuchi[1], Naohiro Ishii[2], Yumiko Tani[3], Kousuke Masaoka[4], Ayaka Suzuki[5], Kazuo Kishi[1]

Department of Plastic and Reconstructive Surgery, [1]Keio University, Shinjuku; [2]Tochigi Cancer Center, Utsunomiya; [3]Ota Memorial Hospital, Ota; [4]Steel Memorial Hirohata Hospital, Himeji; [5]IUHW Mita Hospital, Minato, Japan

Correspondence: Tomoki Kiuchi
Department of Plastic and Reconstructive Surgery, Keio University, 35, Shinanomachi, Shinjuku, Tokyo 160-8582, Japan
Tel: +81-3-5363-3814, Fax: +81-3-3352-1054, E-mail: tomoki_kiuchi86@yahoo.co.jp

No potential conflict of interest relevant to this article was reported.

Received: 3 Nov 2016 • Revised: 28 Nov 2016 • Accepted: 29 Nov 2016
pISSN: 2234-6163 • eISSN: 2234-6171
https://doi.org/10.5999/aps.2017.44.2.175 • Arch Plast Surg 2017;44:175-176

It is important to prepare a suitable microsurgical environment for vascular anastomosis or nerve suture. The background sheet is a useful element of this preparation, as it prevents the tissue and nylon thread from sticking and it can pull the sutured nylon thread. Various types of commercially produced background sheets are used according to the surgeon's preference. In order to investigate the parameters important in background sheets, we emailed a questionnaire to our office staff. The variables included color, elasticity, thickness, availability, workability, and cost. In particular, most respondents pointed out the importance of color. Several papers have described the materials or fashion of background sheets, but no studies have discussed their color. The purpose of our study was to investigate the optimal color of background sheets for microsurgery in reference to chromatic papers. We investigated the visibility of objects due to differences in the color of background on chromatic papers. We prepared a figure in which background sheets of different colors were lined up to compare the visibility of objects. To enhance the visibility of black nylon thread, colors with high luminance were deemed suitable for the background sheet. Additionally, green or blue was appropriate as these colors made the borders of objects (pink vessels) clearly visible and reduced a microsurgeon's discomfort in gazing upon objects. Thus, high-luminance green or blue was the optimal color of background sheets for microsurgery. Several papers have described the materials or fashion of background sheets. The materials include silicone, plastic, rubber, polyethylene, and polypropylene. The category of fashion includes tetragonal, octagonal, and hemispherical shapes. These papers briefly described the colors of background sheets used, which were green, blue, yellow, and "dark" (only for nerve suturing). However, no study has primarily focused on the color of the background sheets. Luminance, hue, and saturation are known as the 3 elements of color. The color of an object may sometimes look different than the original due to the ambient color, a phenomenon known as color contrast [1-4]. Two types of color contrast exist: simultaneous and successive. Simultaneous contrast is due to differences in luminance, hue, and saturation between the object and background. After fixing one's eye on an object's color for a long time, the observer becomes aware of the complementary color (which is point-symmetric to the object's color in the hue circle [5]) afterimage. This undesirable phenomenon is known as successive contrast and referred to as the complementary afterimage phenomenon [2]. We established the optimal color of background sheets taking these color contrasts into account. To enhance the visibility of objects, it is important to distinguish all 3 elements between the object and background. In the microscopic visual field, there are nylon threads (black), vessel (pink), nerve (faint yellow), muscle (red), blood (red), and fat (yellow). When tying off a nylon thread, its visibility is more important than that of other objects. Black is an achromatic color with an undefined hue, and has the lowest luminance and saturation. Hence, colors with high luminance and saturation would enhance the visibility of black nylon thread. However, to avoid discomfort from halation when using colors with high saturation in the visual field, the saturation of the background sheets should be midrange. A background of the object's complementary color clarifies its border due to simultaneous contrast of hue. Fig. 1 presents the hue circle in which 2 colors

Fig. 1. Complementary colors represented in the hue circle

The hue circle illustrates the positions of pink (vessel), red (muscle and blood), and yellow (fat). Two colors symmetrically positioned in this circle are complementary to each other. Green or blue is the complementary color of these objects and is the optimal hue for background sheets.

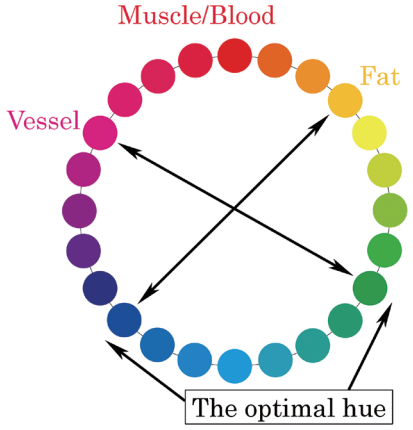
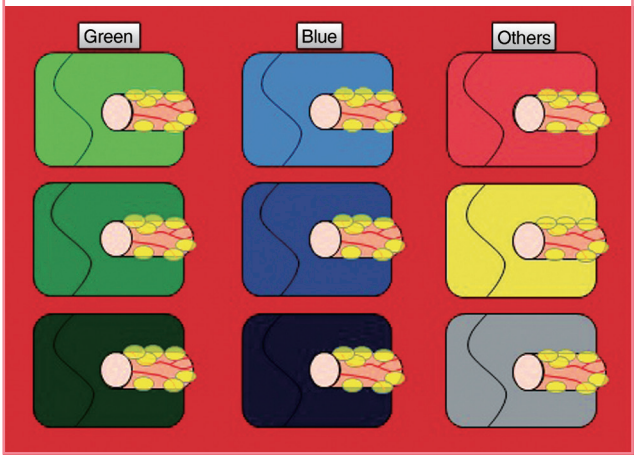


Fig. 2. Visibility of objects in the microscopic field

Differences in visibility caused by the colors of background sheets. The microscopic field is painted dark red. Nylon thread (black), vessel (pink), fat (yellow), and capillary (red) are illustrated. Green and blue sheets are arranged in order of the luminance level (3 types each). The higher the luminance of green or blue, the better the visibility of nylon thread. Red, yellow, and gray are similar in luminance, with the highest luminance in the green and blue sheets. All colors of the background sheets have similar saturation. Since green and blue are the complementary colors of pink and yellow, the borders of objects are clearly visible on these background sheets.



positioned symmetrically are complementary colors of each other. We used the colors of the vessel (pink), muscle/blood (red), and fat (yellow) in the hue circle to identify their complementary colors of green or blue. In addition, a complementary color prevents the microsurgeon from experiencing discomfort due to the complementary afterimage phenomenon. For the same reason, green or blue is used as the color for surgical gowns and drapes in surgery rooms. As a surgeon gazes at red or yellow for a long time during microsurgery, a green or blue background sheet not only clarifies the border of objects, but also effectively relieves the surgeon's discomfort from the complementary afterimage phenomenon. Based on these attributes, we prepared a figure that represents a microscopic field and compared the visibility of objects on background sheets of different colors with similar mid-range saturation. Fig. 2 shows the nylon thread (black), vessel (pink), fat (yellow), and capillary (red) arranged in a microscopic field (dark red). Green and blue background sheets were lined in order of luminance levels (3 types each). Red, yellow, and gray background sheets are shown together (similar in luminance, with the highest being the green and blue sheets). As red is close to the pink color of vessels in hue, the vessel's border was not clear on the red background sheet. Additionally, discomfort from the complementary afterimage phenomenon was a concern with red sheets, eliminating red as the optimal color for background sheets. On a yellow background, the visibility of black nylon thread was relatively good. However, yellow was not the optimal color either, as its hue is close to the pink color of vessels or the yellow color of fat, making the borders of these objects unclear. Though gray is an achromatic color, as is black, the border of the vessel was clearly visible due to simultaneous contrast of saturation. Moreover, the visibility of black nylon thread was good, as gray has a high luminance. However, gray was not the optimal color, since discomfort from the complementary afterimage phenomenon was a concern. In contrast, the higher the luminance of green or blue, the better the visibility of black nylon thread. Additionally, as green and blue are complementary colors of the objects in the microscopic field, the borders of these objects are clear, preventing discomfort from the complementary afterimage phenomenon. In conclusion, high-luminance green or blue colored background sheets can enhance the visibility of nylon thread and vessels as well as relieve the discomfort of microsurgeons. Due to these advantages, we recommend a high-luminance green or blue background sheet for microsurgery.

References

1. Su YR, He ZJ, Ooi TL. Boundary contour-based surface integration affected by color. Vision Res 2010;50:1833-44.
2. Takahashi K, Yamada S, Ono F, et al. Loss of color by afterimage masking. Iperception 2013;4:144-6.
3. Ekroll V, Faul F, Wendt G. The strengths of simultaneous colour contrast and the gamut expansion effect correlate across observers: evidence for a common mechanism. Vision Res 2011;51:311-22.
4. Frome FS, Buck SL, Boynton RM. Visibility of borders: separate and combined effects of color differences, luminance contrast, and luminance level. J Opt Soc Am 1981;71:145-50.
5. Logvinenko AD, Beer A. Color constancy investigated via partial hue-matching. J Vis 2012;12:pii:17.