The Paradigm of Surgical Ellipse Dimensions: Are the Length-to-Width Ratio of 3 to 4 and a Vertex Angle of 30° Correct?

Tamara R. Tilleman1,2*, M. M. Tilleman2, M. H. A. Neumann1
1Dermatology Department, Mohs Micrographic Surgery Unit, Erasmus Medical Center, Erasmus University, Rotterdam, The Netherlands
2Luxon, Inc., Brookline, USA
Email: *ttilleman@gmail.com, mtilleman@gmail.com, h.neumann@erasmusmc.nl

Received November 9, 2012; revised December 11, 2012; accepted January 19, 2013

ABSTRACT
Background: It has been postulated that elliptical cutaneous excisions must possess a length-to-width ratio of 3 to 4 and a vertex angle of 30° or less in order to be closed primarily without creating a “dog ear”. These dimensions became axiomatic in cutaneous surgery and have been taught in the apprenticeship model for years. The present article examines the validity of that paradigm. Methods: We collected data from two sources: ellipses described in the literature (57 cases); and elliptical excisions performed at the authors’ outpatient clinic (83 cases). The surgical ellipse lengths, widths, and vertex angles were analyzed, and the data were compared to a mathematical formula used to generate a fusiform ellipse. Results: The length-to-width ratio of 3 - 4 was found to be inconsistent with the recommended vertex angle of 30°. In fact, a length-to-width ratio of 3 - 4 determines a vertex angle of 48° - 63°. A 30° vertex angle is only feasible with long length-to-width ratio of about 7.5. Conclusions: The paradigm that surgical ellipses should have a vertex angle of 30° with length-to-width ratio of 3 - 4 is incorrect. Evidence from actual surgical practice and from mathematical formulation shows that either the length-to-width ratio must be larger than 3 - 4 or the vertex angle must be larger than 30 degrees.

Keywords: Elliptical Excision; Length-to-Width Ratio of 3 - 4; 30° Vertex Angle

1. Introduction

The surgical ellipse is the classical approach to excising cutaneous lesions [1,2]. This shape, also known as a fusiform ellipse, is the overlap of two ellipses and produces two vertices. It has been postulated that elliptical excisions should possess a length-to-width ratio of 3 to 4 and a vertex angle of 30° or less. Those relationships were thought to enable primary closing of the wound without creating the unfavorable cosmetic result referred to as the “dog ear”. Eventually these dimensions became axiomatic, taught in a system of experience-based medicine that is now gradually being supplanted by evidence-based medicine [3-13].

Applying an evidence-based approach to this commonly used technique, we examined the recommended relationship between the length-to-width ratio and the vertex angle of a surgical ellipse excision, comparing exact measurements of real surgical ellipses with theoretical ellipse dimensions based on a mathematical formula.

2. Methods

To find the underlying rule describing the relationship of the surgical ellipse vertex angle and length-to-width ratio, we analyzed three bodies of data: 1) descriptions of 57 actual surgical ellipses published in the literature; 2) measurements of 83 surgical ellipses excised by the first author; and 3) theoretical ellipse dimensions based on a mathematical formula.

We collected data from the plastic surgery, general surgery, and cutaneous surgery literature. Books and articles from the library of the dermatology and the plastic surgery departments of the hospital Academisch Ziekenhuis Maastricht were surveyed. Over forty references presented drawings or photographs of surgical ellipses [14-55] from which we extracted 57 ellipses, 15 of which were photographed in vivo; the remainders were presented as drawings. Our own consecutive measurements were performed at the authors’ outpatient clinic, extract-
We calculated the vertex angle of a fusiform ellipse by the following mathematical formula [56]:

$$\theta_e \geq 2 \tan^{-1} \left( \frac{1}{a} \right)$$

where $a$ is the length-to-width ratio.

To find the underlying rule relating the dimensions of actual surgical ellipses, we analyzed the data sets identified above. By comparing the clinical ellipses to a mathematical formula of a fusiform ellipse and analyzing the ellipses’ length, width, length-to-width ratios, and vertex angle, we set an empirical law. For these calculations, we assumed a flat, two-dimensional ellipse, model.

3. Results

The ellipse dimensions from the literature and from our clinical data are presented in Figures 1 and 2, respectively. Included in both figures are the plots of the theoretical vertex angles calculated by the above equation, denoted by the pink line.

The length-to-width ratios varied between 1.7 and 6.2, and the vertex angle varied between 32.5° and 110°, with a measurement error of ±2.5° (Figure 1). Assuming a power regression curve, the vertex angle is typified by $\text{DATA} = 128.7 a^{-0.71}$, where $a$ is the length-to-width ratio, with $R^2 = 0.48$. In Figure 2 the clinical ellipses’ length-to-width ratio varies between 1.3 and 6.3, and the vertex angle varies between 42.5° and 118°, with a measurement error of ±1. In both figures we used the average of the two vertices as the vertex angle. Assuming a power regression curve, the vertex angle is typified by $\text{DATA} = 125.5 a^{-0.71}$, with $R^2 = 0.82$. The two power regression curves are very similar, suggesting an underlying empirical law for this relation. However, we must recall that these curves describe only a theoretical fusiform ellipse, while the surgical ellipse is rarely a simple geometric pattern. Figures 1 and 2 demonstrate that the scatter of our original data is significantly smaller than in the literature. A plausible explanation is that excisions made by a single surgeon (the first author) are inherently more uniform than data from multiple sources.

The vast majority of the data describe angles approaching those of a theoretical fusiform ellipse. In contrast, angles corresponding to a length-to-width ratio between 3 and 4 in the literature have best-fit values of $\theta \text{DATA} = 38°$ to 48° (Figure 1) and 59° to 67° (Figure 2, our clinical data). In fact, a 30° angle corresponds to the aspect ratio of 7.5. Table 1 summarizes the vertex angles obtained at the length-to-width ratios of 3 and 4, ranging from 48° to 67°.

4. Discussion

Surgeons regularly excise ellipses with varying length-to-width ratios, resulting in a scar that is cosmetically acceptable to patients. These surgeons use their own judgment, based on the skin tension and the locations of the lesions, to plan the excision; a length-to-width ratio between 3 and 4 often results in a relatively short scar and minimal dog-ear.

This manuscript challenges the accepted surgical paradigm that an ellipse length-to-width ratio of 3 to 4 must have a vertex angle of 30°. This relationship is thought for years as the optimal for resection of lesions without causing dog-ears. Our approach to determining the accurate dimensional relation is based on literature review, analysis of clinical ellipses, and by calculation using basic geometrical principles assuming a flat model, though the human body is often curved and is subject to the effects of skin tension and age laxity.

We found that length-to-width ratios as large as 4 are rarely used in excisional biopsies. The aspect ratio is
We further examined the empirical and calculated relationship between the surgical ellipse’s vertex-angle and length-to-width ratio. The paradigm that surgical ellipses have a vertex angle of 30° with length-to-width ratio of 3 to 4 is incorrect. Evidence reveals the vertex angles to be much larger for a 3 to 4 aspect ratio. The correct elliptical dimensions producing a length-to-width ratio of 3 to 4 are a vertex angle between 48° and 67°. Conversely, the postulated vertex angle of 30° can be achieved only by forming an ellipse with a length-to-width ratio of 7.5. The above results agree with some previous analyses of accepted theory on the apical angle [57] and previously presented empirical length-to-width ratio data from measured surgical ellipses [58].

The authors wish to point out that the surgeon needs to approach each excision with flexibility and an open mind [59,60], realizing that the 30° rule is just an approximation and not always needed. There is no need to change the current practice or to increase in the length-to-width ratio to 7.5, which would needlessly remove skin and produce an excessively long scar. There is no need to stipulate a 3:1 length-to-width ratio for closing wounds as a direct closure of round and elliptical lesions is feasible [60,61] and may result with short scar length.

To conclude, using the principles of evidence-based medicine, we are able to define the accurate dimensions of the surgical ellipse, thus correct a common misrepresentation.

5. Acknowledgements and Contributors

The authors have no conflict of interest in connection with submitted material.

REFERENCES

[1] C. Lee, S. Jankauskas, I. K. Cohen and W. C. Grabb, “Basic Techniques of Plastic Surgery,” In: W. C. Grabb and J. W. Smith, Eds., Plastic Surgery, Little, Brown and Company, New York, 1991, pp. 3-90.

[2] A. Murad, L. H. Goldberg and B. Berkes, “Basic Excisional Surgery,” 2007. http://emedicine.medscape.com/article/1128143-overview

[3] D. L. Sackett, W. S. Richardson, W. Rosenberg and R. B. Haynes, “Evidence-Based Medicine: How to Practice and Teach EBM,” Churchill Livingstone, New York, 1997.

[4] K. C. Chung and A. N. Ram, “Evidence-Based Medicine: The Fourth Revolution in American Medicine?”, Plastic & Reconstructive Surgery, Vol. 123, No. 1, 2009, pp. 389-398. doi:10.1097/PRS.0b013e3181934742

[5] J. G. McCarthy, “Introduction to Plastic Surgery,” In: J. G. McCarthy, Ed., Plastic Surgery, W.B. Saunders Company, Philadelphia, 1990, pp. 1-54.

[6] I. A. McGregor, “Wound Care, and Flaps, Pedicle and Tubes,” In: I. A. McGregor, Ed., Fundamental Techniques of Plastic Surgery and Their Surgical Applications, E&S Livingston Ltd., Edinburgh and London, 1960, pp. 3-141.

[7] M. J. Hudson-Peacock and C. M. Lawrence, “Comparison of Wound Closure by Means of Dog Ear Repair and Elliptical Excision,” Journal of the American Academy of Dermatology, Vol. 32, No. 4, 1995, pp. 627-630. doi:10.1016/0190-9622(95)90349-6

[8] M. J. Hudson-Peacock and C. M. Lawrence, “Excision with Dog Ear Repair Is Superior to Elliptical Excision,” British Journal of Dermatology, Vol. 119, No. 4, 1993, p. 48.

[9] L. M. Dzubow, “The Dynamics of Dog Ear Formation and Correction,” Journal of Dermatologic Surgery & Oncology, Vol. 11, No. 7, 1985, pp. 722-728.

[10] D. B. Robertson, “Dog Ear Repair,” In: R. G. Wheeland, Ed., Cutaneous Surgery, W.B. Saunders Company, Philadelphia, 1994, pp. 295-303.

[11] J. P. R. Rompel, “Dog Ear Repair,” In: J. P. R. Rompel, Ed., Operative Dermatologie, Lehrbuch und Atlas, Springer, Berlin, 1996, pp. 54-55.

[12] J. L. Fewkes, M. L. Cheney and S. V. Pollack, “Complex Excision,” In: J. L. Fewkes, M. L. Cheney and S. V. Pollack, Eds., Illustrated Atlas of Cutaneous Surgery, J.B. Lippincott Company, Philadelphia, 1992, pp. 16.1-16.8.

[13] A. A. Limberg, “Design of Local Flaps,” In: T. Gibson, Ed., Modern Trends in Plastic Surgery, Butterworth & Co., London, 1966, pp. 38-61.

[14] American Society of Plastic Surgeons, “Skin and Subcutaneous Lesions,” Plastic and Reconstructive Surgery Essential for Students, Plastic Surgery Educational Foundation, 1979, pp. 18-30.

[15] D. Marchac, “Techniques of Surgical Repair,” In: D. Marchac, Ed., Surgery of Basal Cell Carcinoma of the Face, Springer-Verlag, Berlin, 1988, p. 14. doi:10.1007/978-3-642-72811-2_4

[16] C. H. Manstein, M. E. Manstein and G. Mansheit, “Creating Curvilinear Scar,” Plastic and Reconstructive Surgery, Vol. 83, No. 5, 1988, pp. 914-915.
[17] A. F. Borges, “Unfavorable Results in Scar Revision,” In: R. M. Goldwyn, Ed., The Unfavorable Results in Plastic Surgery Avoiding and Treatment, Little Brown and Company, Boston, Toronto, 1984, pp. 203-211.

[18] R. G. Wheeland, “Random Pattern Flaps,” In: R. K. Roenigk and H. H. Roenigk, Eds., Dermatologic Surgery Principles and Practice, Marcel Dekker Inc., New York, 1988, pp. 265-273.

[19] M. Maloney, “Basic Skin Surgery Techniques,” In: J. Harper, A. Oranje and N. Prose, Eds., Textbook of Pediatric Dermatology, Blackwell Science Ltd., Oxford, 2000, pp. 1767-1781.

[20] J. L. Fewkes, M. L. Cheney and S. V. Pollack, “Atlas of Cutaneous Surgery and Basic Excisional Technique,” In: J. L. Fewkes, M. L. Cheney and S. V. Pollack, Eds., Illustrated Atlas of Cutaneous Surgery, J.B. Lippincott Company, Philadelphia, 1992, pp. 6.2-6.7.

[21] S. Letessier, Y. Bachellier-Beuzelin and C. Grognard, “The Sutures,” In: S. Letessier, Y. Bachellier-Beuzelin, and C. Grognard, Eds., Practical, High Quality Manual for Dermatologic Surgery, Masson, Paris, 1986, pp. 35-38.

[22] B. Konz and O. Braun-Falco, “Indication Consideration in the Surgical Treatment of Benign Skin Lesions,” In: B. Konz and O. Braun-Falco, Eds., Complications in Surgical Dermatology, Springer-Verlag, Berlin, 1984, p. 145.

[23] B. Konz and G. Burg, “Wound Management in Schlub Dermatotheriegenischen Area,” In: B. Konz and G. Burg, Eds., Dermatotheriegenie in Clinic and Practice, Springer-Verlag, Berlin, 1977, pp. 29-31.

[24] J. Petres and M. Hundeiker, “Surgical Techniques,” In: J. Petres and M. Hundeiker, Eds., Dermatotomography, Springer-Verlag, Berlin, 1978, pp. 42-45.

doi:10.1007/978-1-4615-6811-7

[25] T. I. Jackson, “General Considerations,” In: T. I. Jackson, Ed., Local Flaps in Head and Neck Reconstruction, C.V. Mosby, Saint Louis, 1985, pp. 1-34.

[26] P. R. Kaufmann and E. Country, “Standard Techniques in Surgical Dermatology and Nalhappen Sculptures,” In: P. R. Kaufmann and E. Country, Eds., Dermatologic Surgery, Stuttgart George Thieme Verlag, New York, 1987, pp. 22-23, 45.

[27] F. X. Pletta, “Emergency Room,” In: F. X. Pletta, Ed., Pediatric Plastic Surgery Volume I Trauma, C.V. Mosby Company, Saint Louis, 1967, pp. 5-20.

[28] W. H. J. Chang, “Wound Management,” In: W. H. J. Chang, Ed., Fundamentals of Plastic and Reconstructive Surgery, Williams and Wilkins, Baltimore, London, 1980, pp. 9-61.

[29] E. C. Padgett and K. L. Stephenson, “Skin Flaps,” In: E. C. Padgett and K. L. Stephenson, Eds., Plastic and Reconstructive Surgery, Charles C Thomas, Springfield, 1948, pp. 18-40.

S. Fomon, “Facial Scars,” In: S. Fomon, Ed., Cosmetic Surgery, Principles and Practice, J.B. Lippincott Company, Philadelphia, Montreal, 1960, pp. 134-160.

[30] M. I. Berson, “Wounds,” In: M. I. Berson, Ed., Atlas of Plastic Surgery, Grune and Stratton, New York, 1948, pp. 3-54.

[31] G. Bankoff, “General Technique of Plastic Operations,” In: G. Bankoff, Ed., Plastic Surgery, Medical Publications Ltd., London, 1943, pp. 45-62.

[32] J. N. Barron and M. N. Saad, “An Introduction to Operative Plastic and Reconstructive Surgery,” In: J. N. Barron and M. N. Saad, Eds., Operative Plastic and Reconstructive Surgery, Churchill Livingstone, Philadelphia, 1980, pp. 3-45.

[33] P. Mckinney and B. L. Cunningham, “Fundamental Techniques,” In: P. Mckinney and B. L. Cunningham, Eds., Handbook of Plastic Surgery, Williams and Wilkins, Baltimore, London, 1981, pp. 15-25.

[34] F. Burian, “Closure of Wounds,” In: F. Burian, Ed., The Plastic Surgery Atlas, Butterworths London Czechoslovak Medical Press, Prague, 1967, pp. 19-32.

[35] A. F. Borges, “Linear Scar Revision Techniques,” In: A. F. Borges, Ed., Elective Incisions and Scar Revision, Little, Brown and Company, New York, 1973, pp. 35-60.

[36] J. Penn, L. J. Brown, T. B. Berry, S. A. Schulmeister, J. Royance and C. L. Ormerod, “Fat Loss,” In: J. Penn, Ed., Brenthurst Papers. Problems in Eye Lid and Socket Reconstruction, Witswatersrand University Press, Johannesburg, 1944, pp. 4-16.

[37] W. C. Grabb, “Basic Techniques in Plastic Surgery,” In: W. C. Grabb and J. W. Smith, Eds., Plastic Surgery, a Concise Guide to Clinical Practice, Little, Brown and Company, Boston, 1973, pp. 3-74.

[38] A. J. Barsky, S. Kahn and B. E. Simon, “Free Skin Grafts,” In: A. J. Barsky, S. Kahn and B. E. Simon, Eds., Principles and Practice of Plastic Surgery, McGraw-Hill Book Company, New York, 1964, pp. 34-62.

[39] G. S. Georgiade, R. Riefkohl and L. S. Levin, “Scar Revision,” In: G. S. Georgiade, R. Riefkohl and L. S. Levin, Eds., Georgiade Plastic, Maxillofacial and Reconstructive Surgery, Williams and Wilkins, Philadelphia, 1997, p. 117.

[40] R. J. V. Battle, “Anatomy and Physiology,” In: R. J. V. Battle, Ed., Clinical Plastic Surgery, Plastic Surgery, Butterworths, London, 1965, p. 115.

[41] C. R. Mclaughlin, “Skin Flaps and Pedicles,” In: C. R. Mclaughlin, Ed., Plastic Surgery. An Introduction for Nurses, Faber and Faber Limited, London, 1965, pp. 49-57.

[42] J. C. Mustarde, “Primary Repair,” In: J. C. Mustarde, Ed., Repair and Reconstruction in the Orbital Region, A Practice Guide, Churchill Livingstone, Philadelphia, 1969, pp. 2-16.

[43] L. M. Vistnes, “Basic Principles of Cutaneous Surgery,” In: E. Epstein and E. Epstein Jr., Eds., Skin Surgery, W.B. Saunders Company, Philadelphia, 1987, pp. 44-55.

[44] T. Stasko, “Advanced Suturing Techniques and Layer Closure,” In: R. G. Wheeland, Ed., Cutaneous Surgery, W.B. Saunders Company, Philadelphia, 1994, pp. 304-317.

[45] A. F. Borges, “Dog Ear Repair,” Plastic and Reconstructive Surgery, Vol. 69, No. 4, 1982, pp. 707-713.

doi:10.1097/00006534-198204000-00028

[46] N. K. Weisberg, K. S. Nehal and B. M. Zide, “Dog-Ears:
A Review,” *Dermatologic Surgery*, Vol. 26, No. 4, 2000, pp. 363-370. doi:10.1046/j.1524-4725.2000.98054.x

[47] J. A. Zitelli, “Tips for a Better Ellipse,” *Journal of the American Academy of Dermatology*, Vol. 22, No. 1, 1990, pp. 101-103. doi:10.1016/0190-9622(90)70016-B

[48] R. G. Bennett, “Complex Closure,” In: R. G. Bennett, Ed., *Fundamentals of Cutaneous Surgery*, The C.V. Mosby Company, Saint Louis, 1988, pp. 473-491.

[49] B. Leshin, “Proper Planning and Execution of Surgical Excisions,” In: R. G. Wheeland, Ed., *Cutaneous Surgery*, W.B. Saunders Company, Philadelphia, 1994, pp. 171-177.

[50] E. Dunlavey and B. Leshin, “The Simple Excision,” *Dermatologic Clinics*, Vol. 16, No. 1, 1998, pp. 49-64. doi:10.1016/S0733-8635(05)70486-1

[51] S. J. Stegman, T. A. Tromovitch and R. G. Glogau, “Ellipse,” In: S. J. Stegman, T. A. Tromovitch and R. G. Glogau, Eds., *Basics of Dermatologic Surgery*, Year Book Medical Publishers, Inc., Chicago, London, 1982, pp. 60-68.

[52] G. J. Mackay, G. W. Carlson and J. Bostwick, “Plastic and Maxillofacial Surgery,” In: D. C. Sabiston, Ed., *Textbook of Surgery*, 7th Edition, W.B. Saunders Company, Philadelphia, 1997, pp. 1298-1233.

[53] R. J. Wood and M. J. Jurkiewicz, “Plastic and Reconstructive Surgery,” In: S. I. Schwartz, G. A. Shires, F. C. Spencer, J. M. Daly, J. E. Fischer and A. C. Galloway, Eds., *Principles of Surgery*, 7th Edition, McGraw Hill, New York, 1999, pp. 2091-2143.

[54] W. F. Walker, “Plastic Surgery,” In: W. F. Walker, Ed., *A Colour Atlas of Minor Surgery*, Wolfe Medical Publications Ltd., London, 1986, pp. 134-143.

[55] T. R. Tilleman, M. M. Tilleman, G. A. M. Krekels and H. A. M. Neumann, “Skin Waste and Scar Length in Excisional Biopsies: Comparing Five Excision Patterns: Fusiform Ellipse, Fusiform Circle, Diamond, Mosque and S-Shape,” *Plastic and Reconstructive Surgery*, Vol. 113, No. 3, 2004, pp. 857-861. doi:10.1097/01.PRS.0000105338.66597.A0

[56] B. R. Moody, E. M. McCarthy and R. D. Sengelmann, “The Apical Angle: A Mathematical Analysis of the Ellipse,” *Dermatologic Surgery*, Vol. 27, No. 1, 2001, pp. 61-63. doi:10.1111/j.1524-4725.2001.00242.x

[57] T. R. Tilleman, M. M. Tilleman, N. Smeets and H. A. M. Neumann, “Skin Waste in Elliptical Excision Biopsies,” *Journal of Plastic Surgery and Hand Surgery*, Vol. 40, No. 6, 2006, pp. 352-356. doi:10.1080/02844310601011934

[58] T. R. Tilleman, H. A. M. Neumann and M. M. Tilleman, “Analyses of Skin Waste during Excision of Benign Skin Lesions: Is the Surgical Ellipse Cut Necessary?” *Plastic and Reconstructive Surgery*, Vol. 119, No. 7, 2007, pp. 2343-2345. doi:10.1097/01.prs.0000264311.28833.66

[59] M. Klapper, “The 30-Degree Angle Revisited,” *Journal of the American Academy of Dermatology*, Vol. 53, No. 5, 2005, pp. 831-832. doi:10.1016/j.jaad.2005.06.034

[60] D. Chopp, V. Rawlani, M. Ellis, S. A. Johnson, D. W. Buck II, S. Khan, K. Bethke, N. Hansen and J. Y. Kim, “A Geometric Analysis of Mastectomy Incisions: Optimizing Intraoperative Breast Volume,” *Canadian Journal of Plastic Surgery*, Vol. 19, No. 2, 2011, pp. 45-50.

[61] T. R. Tilleman, “Direct Closure of Round Skin Defects: A Four-Step Technique with Multiple Subcutaneous and Cutaneous ‘Figure-of-8’ Sutures Alleviating Dog-Ears,” *Plastic and Reconstructive Surgery*, Vol. 114, No. 7, 2004, pp. 1761-1767. doi:10.1097/01.prs.0000142417.60242.F5