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

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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 ration 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-

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ed from which are data on 83 surgical ellipses.

We calculated the vertex angle of a fusiform ellipse by the following mathematical formula [56]:

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

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 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 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,

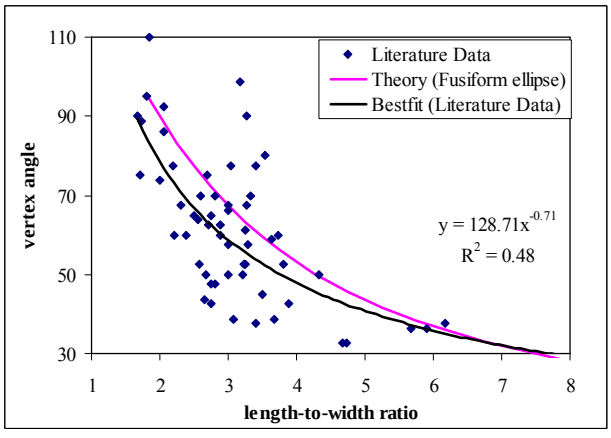

Figure 1. Vertex angle of the cited surgical ellipses as a function of the length-to-width ratio. The data are represented by dots, the black solid line denotes the best-fit curve, and the pink solid line denotes the theoretical curve.

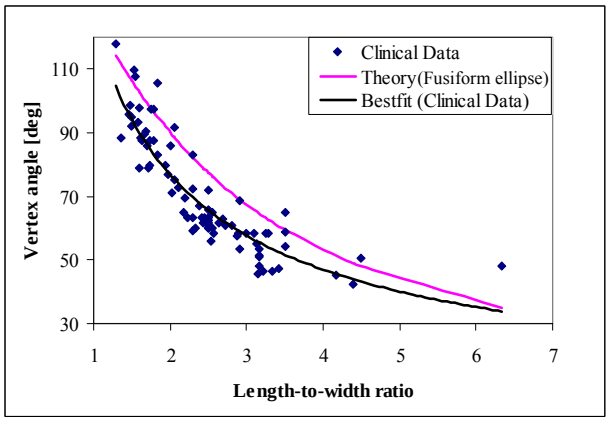

Figure 2. Vertex angle of the clinical ellipses as a function of the length-to-width ratio. The data are represented by dots, the black solid line denotes the best-fit curve, and the pink solid line denotes the theoretical curve.

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 θ DATA = 58˚ to 48˚ (**Figure 1**) and 59˚ to 47˚ (**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 cosmeti cally 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

Table 1. Comparison of empirical vertex angles with theoretical calculations.

	Vertex angle for length-to-width ratio of 3	Vertex angle for length-to-width ratio of 4	Length-to-width ratio for vertex angle of 30˚
Data (literature)	58˚	48˚	7.5
Data (our excisions)	59˚	47˚	7.5
Theory-fusiform ellipse	67˚	53˚	7.5

considerably shorter: an average of 3.1 in the literature and 2.5 in the clinical data.

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 - 4 is incorrect. Evidence reveals the vertex angles to be much larger for a 3 - 4 aspect ration. 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.

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