Spontaneous eyelid expansion after full thickness eyelid resection and direct closure

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Abstract
Background/aims—Direct closure of eyelid defects gives excellent functional results but is usually restricted to defects measuring less than a quarter of the eyelid length for fear of distorting the palpebral aperture and compromising lid function. The authors have used direct closure in larger defects. The aim of this study was to establish the effects of direct closure of full thickness eyelid margin defects under tension on the palpebral aperture dimensions.

Methods—A consecutive series of patients who had undergone one eyelid, full thickness lid resection repaired by direct closure were identified and invited to have both eyes photographed. The palpebral apertures of both eyes were measured from the photographs by a masked observer. The amount of eyelid resected was recorded from the operation notes. The unoperated palpebral aperture was used as the control. The result were analysed using a paired samples t test.

Results—The photographs of 18 patients were included in the analysis. The mean width of excised full thickness lid tissue was 15 mm (range 7–26 mm). The mean vertical palpebral aperture height was 9.2 (SD 1.4) mm in the operated eye as opposed to 9.3 (SD 1.2) mm in the non-operated eye. The mean horizontal palpebral aperture width was 26.1 (SD 1.9) mm in the operated eye as opposed to 26.4 (SD 1.8) mm in the non-operated eye. There was no statistically significant difference between the operated and unoperated horizontal and vertical palpebral measurements.

Conclusions—Direct closure of large full thickness eyelid defects is possible in selected patients with excellent functional and cosmetic results. Eyelid tissue expansion occurs spontaneously following direct eyelid defect closure under tension, restoring the palpebral aperture dimensions.

Many techniques have been described for the management of eyelid margin defects following full thickness resection,1 ranging from simple “laissez faire”2,3 spontaneous healing to the extensive operations such as the Mustardé cheek rotation flap.4 Our experience shows that when applicable, full thickness, direct, horizontal lid closure offers by far the best functional and cosmetic results.

Received wisdom suggests that direct closure of a lid margin defect is possible when a quarter or less of the lid has been resected.4,5 The addition of a lateral cantholysis enables a defect of up to a third of the lid margin to be repaired in this way. For larger excisions there is concern that unacceptable distortion of the palpebral aperture may occur with direct closure and therefore combinations of various flaps and free grafts are usually recommended.1,4,5

In this study, we examined the effect of direct closure of uniconular full thickness lid defects on the dimensions of the palpebral aperture, looking for evidence of shortening.

Method
A consecutive series of patients, who had undergone a uniconular full thickness eyelid resection with direct closure, were identified retrospectively from the operating theatre logbook and case records. Patients who had required cantholysis, flaps, or grafts for reconstruction were excluded from the series.

The operations had all been carried out by the same surgeon (VTT). The posterior lamella was reconstructed by direct end to end suturing of the remaining tarsal plate with 6/0 braided, uncoated, polyglycolic acid sutures (Dexon). If there was no tarsal plate at one end, the remaining tarsal plate was sutured to the canthal tendon stump (posterior limb in the case of the medial canthal tendon) or to orbital rim periosteum, again with 6/0 polyglycolic acid sutures. The lid margin and skin were closed with 6/0 silk or with 6/0 polyglycolic acid. Such direct closure was carried out whenever it was achievable, irrespective of the lid tension, distortion of the palpebral aperture, or globe displacement so induced. A minimum of 3 months had elapsed from the time of surgery to the time of assessment for this study.

The date of the operation, amount of the lid resected, and histological diagnosis were recorded from patient notes.

The patients were invited to return to the outpatient department to have photographs taken of both eyes at a standard 1:2 magnification. Nineteen patients responded to our request. A masked observer (an ophthalmic nurse), who was unaware of the aims of the study, was asked to measure and record, from the photographs, the horizontal and vertical palpebral aperture dimensions of both eyes for each patient (to the nearest millimetre). One patient was excluded from the study as a skin fold obscured the lateral canthus of one eye.
Results
Table 1 summarises the raw data from our series. The horizontal and vertical palpebral aperture measurements of both the operated and non-operated fellow eyes are given.

A total of 18 patients were included in the analysis. Of these, nine (50%) were females, eight (44%) had right eyelid surgery, and in 14 (78%) the operation was on the lower eyelid. Basal cell carcinoma was the pathology in 14 (78%) patients, three (17%) had other pathology including squamous cell carcinoma. In one patient (5%) the underlying pathology was not documented.

The mean age of our patients at time of surgery was 65 (SD 11.8) years and the mean horizontal width of the excised full thickness lid tissue was 15 (SD 4.5) mm with a minimum of 7 mm and a maximum of 26 mm.

The mean vertical palpebral aperture height was 9.2 (SD 1.4) mm in the operated eye as opposed to 9.3 (SD 1.2) mm in the non-operated eye. The mean horizontal palpebral aperture width was 26.1 (SD 1.9) mm in the operated eye as opposed to 26.4 (SD 1.8) mm in the non-operated eye.

Normal probability plots of the vertical and horizontal measurements showed the data to be normally distributed. A paired samples t test showed no significant differences between operated and non-operated sides for vertical palpebral aperture height (p = 0.491) and for horizontal palpebral aperture width (p = 0.282).

### Table 1 Raw data

<table>
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<th>Patient</th>
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BBC = basal cell carcinoma.

Figure 1 These photographs are of a patient not included in the series. (A) The preoperative right lower lid basal cell carcinoma, which measured 11 mm in its horizontal diameter. (B) The 6 month postoperative result after 19 mm horizontal lid resection and direct closure. (C) Also taken at 6 months and allows comparison with the normal unoperated left eye.
There was no significant correlation (Pearson coefficient) between vertical and horizontal measurements of the palpebral aperture in the operated eye and the age or sex of the patient, size of excised lid tissue, underlying pathology or upper versus lower lid surgery.

Discussion
Various reconstructive surgical techniques have been described for the management of eyelid tissue defects. However, numerous complications have also been described. Hawes and Jamell did a study looking into complications of tarsal conjunctival grafts in 44 patients. These include major complications like eyelid retraction, wound dehiscence, ectropion, and excessive lower lid laxity.

The most striking finding of our study is the excellent cosmesis and normal function achieved by direct closure. A typical example is shown in Figure 1. The reconstructed lid margins have a normal appearance of uniform thickness (unlike that achieved after lateral cantholysis) and they have eyelashes along their whole length. The red margin, so often seen after posterior lamellar reconstruction, was notable by its absence. There was no contact of skin epithelium or skin hairs in with the cornea to cause irritation. In these respects, direct closure is far superior to the results of spontaneous granulation (the laissez-faire technique) or other more involved reconstructions.

Our results show that large amounts of lid tissue can be resected without significant alteration of the ultimate palpebral dimensions. In our series the amount of resection ranged between 29% and 108% of the horizontal palpebral aperture with an average of 58%. The outlier, case number 9, seems at first sight impossible. However, the total eyelid length is the lateral orbital tubercle to posterior lacrimal crest curve, rather than the more readily observable lateral to medial canthus horizontal palpebral aperture measured in this study. This particular patient has relatively short palpebral apertures, which will misleadingly inflate the resection percentage. Furthermore, the resection extended laterally past the lateral canthus and so the measurement quoted is not entirely composed of lid margin.

How is it possible to achieve direct closure after such large resections? At surgery, achieving direct closure is often difficult. It causes extreme tension in the remaining lid and usually causes globe displacement in an upward direction. This can temporarily interfere with normal vision and lid function. We surmise that the factors that make direct closure possible are as follows:
1. Pre-existing eyelid and canthal tendon laxity.
2. Inherent eyelid elasticity.
3. Straightening of the normal lid curvature (arc to chord conversion) by globe displacement (Fig 2).
4. The “mechanical tissue creep” phenomenon talked of in relation to tissue expander use under the skin.

(1) PRE-EXISTING EYELID AND CANTHAL TENDON LAXITY
The first factor is self explanatory and probably correlates with age. We found no age correlation in our results, however. This is probably because our series is biased, our cases having been retrospectively selected based on successful direct closure.

(2) EYELID ELASTICITY
Eyelid elasticity requires quantification and is currently the subject of a further study.

(3) STRAIGHTENING OF THE NORMAL LID CURVATURE
When an eyelid is maximally shortened between two fixed points, the arc of its natural curve is converted to a straight line (chord). This is possible because the eye itself can be displaced within the orbit by the tight lid, allowing the lid to straighten. If one assumes the normal lid curve to be an approximate arc and knows the exophthalmometry reading and the horizontal orbital rim aperture then one can estimate the change in lid length caused by straightening the arc by applying the formula in Figure 2. Substituting 35 mm for the chord (horizontal orbital rim aperture) and 10 mm for the central exophthalmometry measurement, then, according to the formula in Figure 2 this straightening allows approximately 7 mm lid shortening; a central exophthalmometry measurement of 15 mm allows 15 mm shortening and a central exophthalmometry measurement of 20 mm allows 31 mm. Consequently suturing under maximal tension can cover that much additional tissue deficit. Clearly, the exact amount depends on each individual patient’s anatomical dimensions and the figures used here are merely illustrative. The greater the natural lid curvature (degree of proptosis), the more the lid can be shortened by pulling it straight. If one expresses the illustrative measurements calculated above as a percentage of the mean horizontal palpebral...
aperture found in our study of 26 mm, the figures are 27%, 58% and 196% respectively. Clearly this is an important factor.

(4) MECHANICAL TISSUE CREEP

Mechanical tissue creep is the immediate, intraoperative tissue stretching which is known to occur during rapid intraoperative tissue stretching. It may be explained by four factors:
(a) Displacement of fluid and ground substance out of the collagen network leading to relative tissue dehydration. This is brought about by the stretching force mechanically squeezing fluid from the cells and connective tissue.
(b) Realignment of collagen fibres in a parallel fashion;
(c) Microfragmentation of elastic fibres; and
(d) Migration of adjacent tissue into the expanded field.

Whether these factors operate in the same way in eyelid tissue, which contains tarsal plate whose properties are likely to be different from skin, has not yet been established. It is well known that skin stretches under tension. Neumann first described tissue expansion in 1957. Many surgeons make use of this property to perform various reconstructive operations. Skin tissue can be expanded either as a controlled operation or more recently as rapid intraoperative tissue expansion.

Other tissues can also be expanded. Indeed, this property is exploited by scientists in tissue engineering. By applying different tension stress on cultured osteocytes, bony tissue of different physical properties can be produced.

It is difficult to tell how much tissue can expand. Studies have shown that skin can expand up to between 35–59%, 14, 16, 17 The mechanism of tissue expansion is still not well understood. Gibson et al. apply the principles of engineering in describing the biomechanical properties of skin under tension. Mechanical creep refers to the viscoelastic ability of the skin to acutely stretch in an incremental fashion. Biological creep refers to the actual generation of new tissue secondary to a persistent, chronic stretching force. As mentioned above mechanical creep is one of the factors that makes direct closure under tension possible.

Although the operated lid may be under considerable tension at the end of surgery, it seems to relax within a matter of days. Generally, by 2 months the lid has expanded to normal proportions. This is why a minimum interval of 3 months from surgery was chosen in this study. This relaxation of the tension is known as biological tissue creep and is characterised by increased cell mitosis, collagen synthesis, and vascularisation of the stretched tissue. Within 24–48 hours of tissue being stretched, there is a burst of mitotic activity in the basal cell layer. 18, 22 Intercellular space reduces with time. Dermis thickness is reduced whereas the epidermis is thickened. Fibroblasts and myofibroblasts increase in number. Collagen synthesis is increased, as demonstrated with immunohistochemical staining with a monoclonal procollagen antibody. Subcutaneous fat and muscle atrophy with expansion. However, the function of the muscle appears to be maintained. Angiogenesis and vasodilatation also occur.

Although most studies are based on tissue being stretched with expanders, we believe that such a process also takes place in direct lid closure under tension. The displaced globe itself may be considered as the tissue expander, providing the steady sustained force necessary for lid expansion. The results presented here support our hypothesis that eyelid tissue expansion does occur after direct closure under tension. Such eyelid expansion is also observed in other ophthalmic conditions, such as mechanical ectropion, the floppy eyelid syndrome, and in plexiform nevroma of the eyelid. The late failure of some eyelid tightening operations, such as lower lid tightening for a heavy enucleation prosthesis or ectropion recurrence after successful surgery, may also be due to eyelid tissue expansion. Whether it is entirely mechanical or whether humoral growth factor mediation is involved remains to be established.

Why should direct closure be used in preference to the previously described techniques of controlled expansion or intraoperative tissue expansion? The latter two techniques are primarily intended to expand a skin and muscle flap and not the lid margin and tarsal plate which are expanded with the direct closure we describe. Secondly the expansion techniques rely on dissection and undermining of the tissues to be stretched which their authors acknowledge risks damaging the blood supply. Furthermore, such dissection creates subcutaneous scarring which may limit subsequent lid mobility and give rise to late contraction and ectropion. Our technique avoids these risks and the complications of expander infection, haematoma formation and flap necrosis. Finally direct closure is a simpler technique to perform and to teach.

Conclusion

We have demonstrated that in selected cases direct eyelid closure may be achieved after considerably larger lid margin resections than conventionally taught. The immediate postoperative distortion and reduction in palpebral aperture is temporary thanks to spontaneous tissue expansion brought about by the steady pressure of the displaced globe against the reconstructed lid. The surgery is simple and the functional and cosmetic results are excellent. In the event of histologically incomplete tumour resection subsequent re-excision for additional clearance would not present the problems that other reconstructive techniques might. Should postoperative wound dehiscence occur the defect may be allowed to granulate as in the “laissez faire” method. Subsequent excision of any notch or delayed reconstruction would still be viable options and made easier by the decrease in defect size. For these reasons we strongly recommend that direct closure of eyelid defects, even under

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maximal tension, be considered as the primary procedure of choice, irrespective of defect size. It will be abundantly clear on the operating table if direct closure is unattainable and an alternative reconstruction is needed.

This is a retrospective, selective study and leaves many questions unanswered. A larger prospective study is needed to quantify the amount of expansion achievable, the time course of such expansion and the possible drawbacks and complications. Surgical ingenuity will surely find a way to extend this technique to defects that currently defy apposition, even under maximal tension.

Our grateful thanks go to the patients who consented to participate in this study, to Mr S Slater, medical photographer at the Royal Eye Infirmary for the photographs, and to Mr David Acheson of Jesus College, Oxford, for his help with the geometric formula. We dedicate this study to the fond memory of nurse Norah Brown, who was our masked observer, and who has since sadly died.

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Conflict of interest: None.