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How to knot bury and not break the suture: the 3-1-bury-1 knot



Suturing of a wound is typically performed for incisions that fail to seal after stromal hydration or after other anterior segment procedures, such as penetrating keratoplasty.^{1–4} On tying a suture of appropriate tension, rotation and burying of the knot is important to prevent foreign body sensation and irritation to the palpebral conjunctiva.^{3–6} However, the knot can break or slip during rotation and burying of the knot.

The 3-throw, “3-1-1” approach, also known as the surgeon’s knot, is a traditional suture tying technique employed routinely in ophthalmology.⁶ However, when tied, this knot typically has a cross-sectional area significantly larger than its accompanying needle tract. As a result, a surgeon may have difficulty burying the knot into the corneal stroma or limbal tissue. The force required to bury this knot may exceed the tensile strength of the suture, leading to suture breakage. Some alternatives, such as the “3-1”, the “2-1-1” square knot, the “1-1-1” slip knot, and “1-1-1-1” modified slip knot, have been used.^{3,6–8} These techniques reduce the size of the knot and, in the case of the slip and modified slip knot, allow adjustment of suture tension until locked.³ However, these knots tolerate significantly less tensile force. For instance, in one study, the modified slip knot tolerated 0.64 N before breakage and 0.37 N before slippage, whereas the surgeon’s knot tolerated 0.71 and 0.48 N, respectively.⁴ In another study, the slip knot and modified slip knot demonstrated greater than 2 times more slippage after 24 hours than the surgeon’s knot.⁷ Herein, we present an alternative technique for tying a 3-1-1 square knot, reducing its cross-sectional area while burying the knot, thus reducing the likelihood of suture breakage.

A 10-0 nylon suture is placed across the wound (Video 1). The first throw comprises 3 loops and may be adjusted to the

desired tension (Fig. 1A,B). The second throw uses 1 loop in the opposite direction to the first throw. This creates a locking square knot (Fig. 1C,D). The knot is buried (Fig. 1C,D). The third and final throw is a single loop that is tied in the opposite direction to the second throw to lock the knot securely (Fig. 1E). The ends of the sutures are then trimmed using a 75-blade. The final step pulls the knot from its buried position but may be buried once again with relative ease (Fig. 1F).

In the traditional 3-throw, 3-1-1 technique, the initial loops limit the suture from slipping, permitting the appropriate tension to be maintained during the second and third throws, each of which secures the knot further. This ultimately results in a strong knot that is resistant to breakage and unravelling. However, this technique has its disadvantages, including appropriate tensioning and its large size, making it more difficult to bury.

Attention must be made to bury all corneal and limbal knots to reduce corneal irritation. For these reasons, smaller knots have been developed (e.g., 3-1, 2-1-1 square knots, the 1-1-1 slip knot, and 1-1-1-1 modified slip knot). Each of these techniques produces a smaller knot that requires less force when burying.^{4,7,8} The slip knot and modified slip knot in particular offer the additional benefit of tension adjustment until after the third throw. The trade-off, however, is that these alternatives produce sutures with reduced tensile strength compared with the traditional 3-1-1 technique.^{4,8}

In the 3-1-bury-1 technique, the cross-sectional area of the knot is smaller after the second throw than that of the standard 3-1-1 knot. This reduced cross-sectional area allows the knot to be more easily rotated into the corneal stroma. This initial burying of the knot enlarges the suture needle tract. During the subsequent throw, the knot retracts from the corneal stroma but is easily rotated back into the previously widened path, thus minimizing the potential for suture breakage. Ultimately, this may limit the need to replace sutures, decrease operating time, and reduce associated complications.

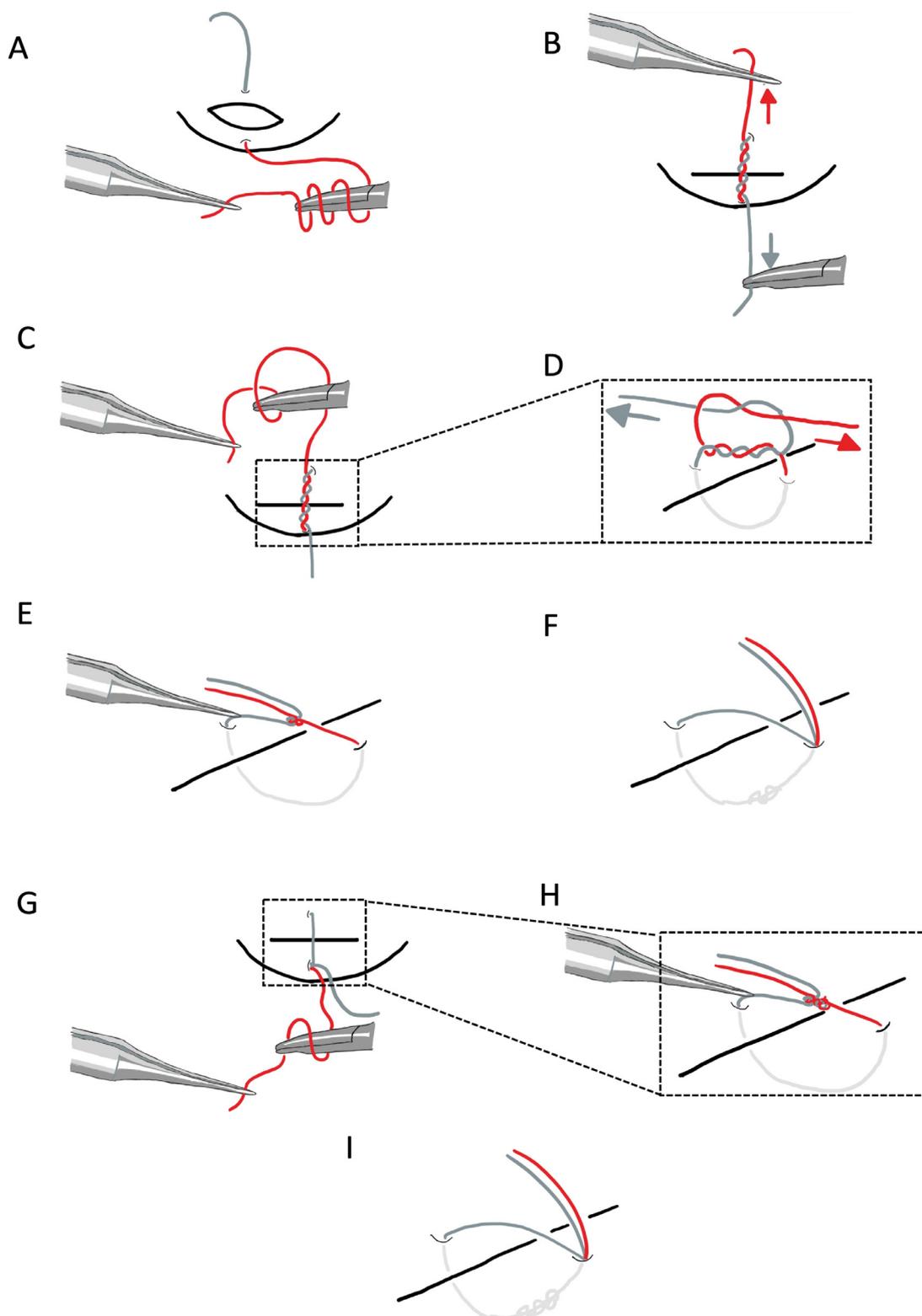


Fig. 1—The suture is passed in a cornea-to-scleral or scleral-to-corneal direction through the wound. (A) The first throw is made forward with tying forceps between the 2 ends of the suture with 3 loops made in the same manner as the traditional 3-1-1 technique. (B) The short end of the suture line is then pulled through the loops in the opposite direction and the knot set to the desired tension. (C) The second throw is made with a single loop and (D) tightened to lock the knot. (E) Using forceps, the knot is rotated and (F) buried. (G) The final throw is made with 1 loop. (H) This will unbury the knot (I), which is then reburied.

SUPPLEMENTARY MATERIALS

Supplementary material associated with this article can be found in the online version at <https://doi.org/10.1016/j.jcjo.2019.02.014>.

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Prominent corneal nerves, conjunctival neuromas, and dry eye in a patient without MEN2B



Multiple endocrine neoplasia (MEN) encompasses a group of hereditary tumour syndromes of variable neoplastic patterns in which tumours concomitantly develop in 2 or more endocrine glands.¹ Its mode of inheritance is autosomal dominant with high penetrance and variable expressivity.² MEN syndromes have been classified into 3 different types: MEN1, MEN2 (MEN2A and MEN2B), and MEN4. Various ocular manifestations of MEN are classically described only in MEN2, especially MEN2B.² MEN2B, also known as MEN3, consists of medullary thyroid carcinoma, adrenal pheochromocytoma, and absent parathyroid hyperplasia. Phenotypic characteristics of MEN2B include hypertrophic lips, marfanoid habitus, ocular and musculoskeletal abnormalities, generalized mucosal neuromas, and intestinal ganglioneuromas.³ MEN2B is localized to chromosome 10 and is caused by a defect in the *RET* (rearranged during transfection) proto-oncogene.⁴

Typical ocular finding of MEN2B is prominent corneal nerves (100%). Other characteristic ocular features include conjunctival and eyelid neuromas (80%–87%), dry eye disease (67%), thickened upper eyelids, and prominent perilimbal blood vessels.^{2,5} Although corneal nerves could be more visible in other diseases, including MEN2A, phytanic acid storage disease (Refsum syndrome), Hansen disease (leprosy), familial dysautonomia (Riley-Day syndrome), neurofibromatosis, congenital ichthyosis, and some corneal diseases, such as Fuchs'

bullous keratopathy, keratoconus, posterior polymorphous dystrophy, herpes simplex and zoster keratitis, they are usually less prominent.^{5,6} Therefore, prominent corneal nerves in a clear corneal stroma may be the first clue of MEN2B, particularly in combination with multiple neuromas of conjunctiva, eyelids, lips, and tongue.^{5,7} Early diagnosis of MEN2B provides a narrow window of opportunity for prophylactic thyroidectomy to prevent medullary thyroid carcinoma.⁸

However, 10 cases of prominent corneal nerves and mucosal neuromas, but no evidence of medullary thyroid carcinoma, adrenal pheochromocytoma, or *RET* gene mutations, have previously been described in the literature.^{6,9–12} Among the 10 cases, only 1 case had mucosal neuromas along the eye,¹⁰ whereas the other 9 had neuromas at nonocular sites.^{6,9,11,12} Dry eye disease has never been clearly documented in any case. Herein, we report a patient with prominent corneal nerves, conjunctival neuromas, and dry eye disease, who did not have characteristic endocrinopathies or *RET* gene mutations of MEN2B.

CASE REPORT

A 33-year-old Thai female presented with red eye and small conjunctival nodules in both eyes. She noted that the conjunctival nodules gradually enlarged over a 1-year period. She often had ocular irritation and dryness. Her past medical, ocular, and family histories were all unremarkable. She was not currently taking any medications or eye drops.

Uncorrected visual acuity was 20/20 in each eye. Slit lamp examination showed mild thickening of the eyelid margins