

EP-128

외과적 매듭 유형에 따른 매듭 안정성 비교: 평평한 매듭 형성의 영향

(Comparison of knot security in various surgical knots: Impact of flat tying)



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Purpose: Surgeon's knot which is based on the flat knot is a standard in surgical suture. However, unequal tension on both hands during flat knot formation may convert it into a sliding form, which we termed "sliding surgeon's knot". This study compares security of sliding surgeon's knot with other surgical knots.

Methods: Six knot configurations were tested using 4-0, 5-0, 6-0, and 7-0 nylons: sliding surgeon's knot (SU[S]), flat surgeon's knot (SU[F]), four-throw sliding knot (S[4]), four-throw flat knot (F[4]), three-throw sliding knot (S[3]) and three-throw flat knot (F[3]). Knots were tied under standardized conditions and tested with a universal testing machine (H5KT; Tinius Olsen Co). Primary outcomes were maximal force to failure (N) and elongation at yield (mm).

Results: SU[F] showed greater strength and elongation than SU[S] in 4-0, 5-0, and 7-0 nylons, particularly in 4-0 Nylon (20.60 N and 7.64 mm, $p < 0.0001$). In 6-0 nylon, F[4] showed highest breaking strength of 4.92 N and SU[F] showed maximal elongation of 10.91 mm. Flat knots revealed better knot security than sliding knots in equal throw counts. In all suture materials, F[3] and F[4] showed no difference, whereas F[3] was superior to S[4]. Although F[4] performed better than SU[S] in 4-0 and 5-0 nylons, differences were not significant in 6-0 and 7-0 nylons.

Conclusion: Flat surgeon's knot surpassed other surgical knots in most suture materials. Maintaining flat configuration was more important than throw

count for knot security. Therefore, proper formation of flat surgeon's knot with balanced tension on both hands is important to prevent unintended sliding and maintain knot security.

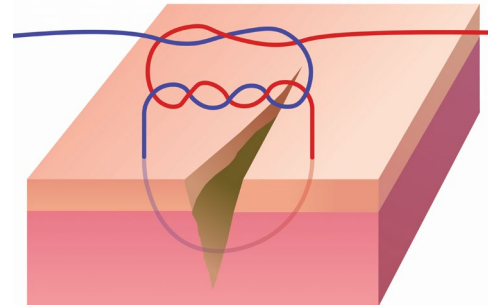


Fig. 1. The flat surgeon's knot with a double loop in the first throw followed by square knot.

Fig. 2. The sliding surgeon's knot in which imbalance of tension between the two hands converts both the first double loop and the second square knot into a sliding form.



Fig. 3. Clinical photograph of three-throw flat surgeon's knot.



Fig. 4. Clinical photograph of three-throw sliding surgeon's knot.