Effectiveness of Fibrin Adhesive in Facial Nerve Anastomosis in Dogs Compared With Standard Microsuturing Technique

Bijan Movahedian Attar, DDS, MS, Haidar Zalzali, DDS,†*
Mohammad Razavi, DDS, MS,‡ Mehdi Ghoreishian, DDS, MS,§
and Majid Rezaei, DDS, MS||

Purpose: Epineural suturing is the most common technique used for peripheral nerve anastomosis. In addition to the foreign body reaction to the suture material, the surgical duration and difficulty of suturing in confined anatomic locations are major problems. We evaluated the effectiveness of fibrin glue as an acceptable alternative for nerve anastomosis in dogs.

Methods: Eight adult female dogs weighing 18 to 24 kg were used in the present study. The facial nerve was transected bilaterally. On the right side, the facial nerve was subjected to epineural suturing; and on the left side, the nerve was anastomosed using fibrin adhesive. After 16 weeks, the nerve conduction velocity and proportion of the nerve fibers that crossed the anastomosis site were evaluated and compared for the epineural suture (right side) and fibrin glue (left side). The data were analyzed using the paired t test and univariate analysis of variance.

Results: The mean postoperative nerve conduction velocity was 29.87 ± 7.65 m/s and 26.75 ± 3.97 m/s on the right and left side, respectively. No statistically significant difference was found in the postoperative nerve conduction velocity between the 2 techniques ($P = .444$). The proportion of nerve fibers that crossed the anastomotic site was $71.25\% \pm 7.59\%$ and $72.25\% \pm 8.31\%$ on the right and left side, respectively. The histologic evaluation showed no statistically significant difference in the proportion of the nerve fibers that crossed the anastomotic site between the 2 techniques ($P = .598$).

Conclusions: The results suggest that the efficacies of epineural suturing and fibrin gluing in peripheral nerve anastomosis are similar.

J Oral Maxillofac Surg 70:2427-2432, 2012

Injury to the peripheral nerves in the head and neck, including the inferior alveolar, lingual, and facial nerves, is not uncommon and can occur from maxillofacial trauma and iatrogenic causes during the practice of dentistry and medicine. The iatrogenic causes include maxillary and mandibular orthognathic surgery, esthetic surgery, dentoalveolar surgery, and injection of local anesthesia. These nerve disturbances often undergo spontaneous recovery; however, some can be permanent and require surgical intervention.[1-4] Several techniques have been described in published reports for peripheral nerve repair, including suturing, gluing,[5,6] grafting,[7] and laser welding.[8] At present, epineural suturing is the most commonly used method for peripheral nerve anastomosis. However, this technique is not the ideal method and has many disadvantages. These disadvantages include foreign body reactions to the suture material,[9-11] excessive handling and manipulation of the nerve ends, conse-

*Associate Professor, Department of Oral and Maxillofacial Surgery and Torabinejad Dental Research Center, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran.

†Resident, Department of Oral and Maxillofacial Surgery, Alzahra Hospital, Isfahan University of Medical Sciences, Isfahan, Iran.

‡Associate Professor, Department of Oral and Maxillofacial Pathology and Torabinejad Dental Research Center, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran.

§Associate Professor, Department of Oral and Maxillofacial Surgery, School of Dentistry, Isfahan University of Medical Sciences, Isfahan, Iran.

||Resident, Department of Oral and Maxillofacial Surgery, Alzahra Hospital, Isfahan University of Medical Sciences, Isfahan, Iran.

Address correspondence and reprint requests to Dr Zalzali: Department of Oral and Maxillofacial Surgery, Alzahra Hospital, Isfahan University of Medical Sciences, Isfahan Dental School, Hezar Jareb Avenue, Isfahan, Iran; e-mail: zalzali@dnt.mui.ac.ir

0278-2391/12/7010-0$36.00/0
doi:10.1016/j.joms.2011.11.007

quent trauma from needle penetration through nerve tissue, and difficulty suturing in confined anatomic locations.

The possibility of performing nerve anastomosis without the use of sutures and with accurate approximation of the nerve ends would be ideal because this would limit fibrosis and inflammation, which could interfere with axon sprouting.

Recently, attention has been paid to replacing the suture neuroanastomosis techniques with adhesives, including fibrin and cyanoacrylate glues, to overcome the accompanying difficulties.[1,12]

Cyanoacrylate, when used as a tissue adhesive, has been shown to induce a stronger tissue reaction than nonresorbable sutures, resulting in a more pronounced foreign body inflammatory reaction. Others have also found it to cause tissue necrosis in vivo.[13,14]

Fibrin adhesive, unlike cyanoacrylate and nylon suturing, causes no foreign body reaction or scarring, because it is a physiologic component found in tissue repair.[15-18] It is easily applied, involves less tissue handling and consequent trauma to the nerve ends, and facilitates the reanastomosis of the nerve stumps.

The purpose of the present study was to assess the effectiveness of using fibrin adhesive in facial nerve anastomosis compared with the microsuturing technique. We hypothesized that fibrin glue and epineural sutures will have similar effectiveness in peripheral nerve repair. The specific aims of the present study were to compare the nerve conduction velocity (NCV) and proportion of the nerve fibers that crossed the anastomotic site of epineural suture and fibrin glue.

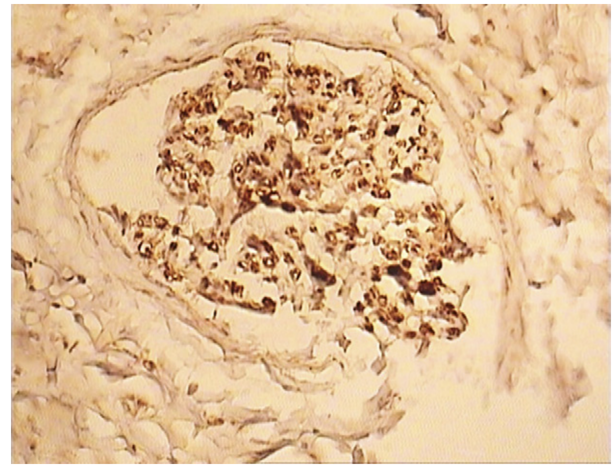

FIGURE 1. Photomicrograph showing cross-section of distal segment of facial nerve in suture group (hematoxylin and eosin stain, original magnification ×400).

Attar et al. Effectiveness of Fibrin Glue. J Oral Maxillofac Surg 2012.

Materials and Methods

STUDY DESIGN

Eight adult female dogs weighing 18 to 24 kg were used in the present prospective animal study. The study was approved by the Torabinejad research center animal care and use committee. All surgical procedures were performed by the same surgeon. General anesthesia was achieved with intramuscular injection of 50 mg/kg ketamine and 5 mg/kg acepromazine maleate.

SURGICAL TECHNIQUE

Fur was shaved from both periauricular areas of each dog. After preparing and draping, a 2-cm incision was made directly over the zygomatic arch. After tissue dissection, the frontal branch of the facial nerve was identified, isolated, and transected. Before nerve transection, the NCV was determined using PowerLab (ADInstruments, Sydney, Australia). On the right side, the nerve was anastomosed with 3 epineural microsutures using 8-0 nylon suture. On the left side, fibrin glue (Tisseel, Baxter AG, Vienna, Austria) was used for nerve anastomosis. When applying the fibrin glue, the edges of the nerve stumps were manually approximated using forceps, and drops of glue were then applied over the apposed nerve edges using a double-syringe system (DUPLOJECT System, Baxter International, Deerfield, IL). The nerve ends were then held for 60 seconds to allow complete setting at body temperature. Before closing the skin incision, a mark was made close to the anastomosis site using 4-0 silk suture to facilitate its identification in the second surgery. All skin incisions were closed using 3-0 nylon suture. The skin sutures were removed after 2 weeks.

ELECTROPHYSIOLOGIC AND HISTOLOGIC EVALUATIONS

After 16 weeks, the previous operative site was re-entered. After identification of the anastomosis site, the NCV was determined on both sides using the following formula: NCV = distance between stimulation sites/difference between latencies, where the distance between the stimulation sites was taken as the distance between the stimulating electrode and the recording electrode in meters, and the difference in latencies was taken as the time from stimulus to peak response in seconds. A 6-mm nerve specimen (3 mm proximal and 3 mm distal to the anastomosis site) was harvested from each nerve. Next, the nerve stumps were reanastomosed using 8-0 nylon suture. The specimens were fixed in 10% formalin solution and stained with hematoxylin and eosin. Two 6-μm-thick cross-section preparations were made from each specimen (1 from the proximal and 1 from the distal segments of the anastomosis site). Histologic

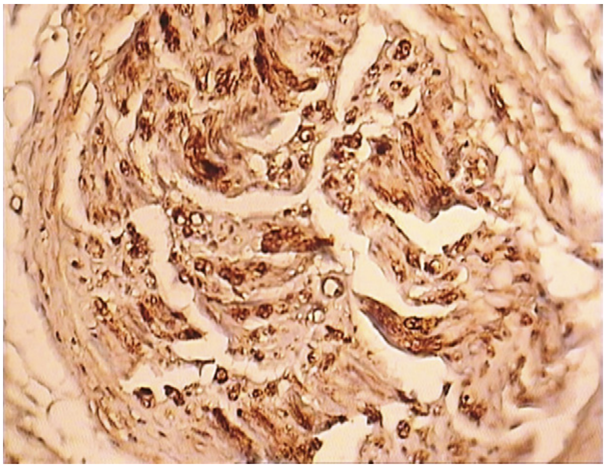

FIGURE 2. Photomicrograph showing cross-section of distal segment of facial nerve in fibrin glue group (hematoxylin and eosin stain, original magnification × 400).

Attar et al. Effectiveness of Fibrin Glue. J Oral Maxillofac Surg 2012.

evaluation was done using light microscopy at a magnification of ×400. The number of the nerve fibers in the proximal and distal segments of each specimen was counted by a histologist who was unaware of the surgical techniques (Figs 1 and 2). Next, the proportion of the nerve fibers that crossed from the proximal to the distal part of the anastomosed nerve (PNF) was calculated: PNF = number of nerve fibers in distal segment/number of nerve fibers in proximal segment × 100.

STATISTICAL ANALYSIS

Two variables were analyzed in the present study: an electrophysiologic continuous variable (NCV) and a histologic discontinuous variable (proportion of the nerve fibers that crossed the anastomotic site). The postoperative NCV on both sides was analyzed using univariate analysis of variance, and the paired *t* test was used to analyze the PNF on the right and left sides.

Table 1. CONDUCTION VELOCITY OF FACIAL NERVE IN EPINEURAL SUTURE VERSUS FIBRIN GLUE TECHNIQUES

Variable	Conduction Velocity (m/s)		*P* Value*
	Epineural Suture	Fibrin Glue	
Preoperative	51.02 ± 8.33	48.53 ± 7.16	.316
Postoperative	29.87 ± 7.65	26.75 ± 3.97	.444
P Value†	< .001	< .001	—

*Univariate analysis of variance.
†Paired *t* test.

Attar et al. Effectiveness of Fibrin Glue. J Oral Maxillofac Surg 2012.

Table 2. NERVE FIBER COUNT AND PROPORTION OF NERVE FIBERS THAT CROSSED ANASTOMOSIS SITE OF FACIAL NERVE IN EPINEURAL SUTURE AND FIBRIN GLUE TECHNIQUES

Variable	Epineural Suture	Fibrin Glue	*P* Value*
NFC in proximal segment	138.75 ± 34.34	143.25 ± 27.15	.327
NFC in distal segment	98.37 ± 23.56	103.12 ± 21.01	.265
PNF (%)	71.25 ± 7.59	72.25 ± 8.31	.598

Abbreviations: NFC, nerve fiber count; PNF, proximal to distal part of anastomosed nerve.
*Paired *t* test.

Attar et al. Effectiveness of Fibrin Glue. J Oral Maxillofac Surg 2012.

Results

ELECTROPHYSIOLOGIC TESTING

The mean preoperative NCV was 51.02 ± 8.33 m/s and 48.53 ± 7.16 m/s on the right (epineural suturing) and left (fibrin glue) sides, respectively. The postoperative NCV was 29.87 ± 7.65 m/s and 26.75 ± 3.97 m/s on the right and left sides, respectively (Table 1). Comparison using the paired *t* test revealed a statistically significant decrease in the mean NCV between the preoperative and postoperative measurements for both epineural suturing ($P < .001$) and fibrin gluing ($P < .001$). The difference in the postoperative NCV between the right and left sides was analyzed using univariate analysis of variance. No statistically significant difference was found between the postoperative NCV on the right and left sides ($P = .444$).

HISTOLOGIC EVALUATION

The mean number of nerve fibers of the proximal segment was 138.75 ± 34.34 and 143.25 ± 27.15 on the right and left sides, respectively. The mean number of nerve fibers in the distal segment was 98.37 ± 23.56 and 103.12 ± 21.01 on the right and left sides, respectively. The PNF was 71.25% ± 7.59% and 72.25% ± 8.31% on the right and left sides, respectively (Table 2). Using the paired *t* test, no statistically significant difference was found between the PNF on both sides ($P = .598$).

Discussion

The purpose of the present study was to assess the effectiveness of using fibrin adhesive in facial nerve anastomosis compared with the microsuturing technique. We hypothesized that fibrin glue and epineural suturing have similar effectiveness in peripheral nerve repair. The specific aims of the present study were to compare the NCV and PNF of epineural suturing and fibrin glue. In the present study, fibrin glue (Tisseel) was used as an alternative to epineural suturing for the anastomosis of the facial nerve in dogs. The results showed that fibrin glue can be a good alternative to epineural suturing in nerve anastomosis. After 16 weeks of anastomosis, the NCV and PNF were similar between the 2 sides undergoing epineural suturing and fibrin gluing.

Anastomosis with epineural suturing is the reference standard for the repair of an injured nerve[19]; however, this technique further traumatizes the nerve fibers,[20] takes a considerably long time,[21] can cause foreign body reactions,[9-11] and can be difficult to perform when surgical access is limited. It can also result in the formation of suture granulomas, which obstruct myelin regeneration and axon sprouting.[22]

The idea of using tissue adhesives for nerve anastomosis seems attractive owing to the theoretical advantages of less tissue handling, and consequent trauma, and the ease of performance in confined anatomic locations.

Fibrin was first noted to have a hemostatic effect on wounds by Bergel[23] in 1909 and was subsequently used by Grey,[24] who applied fibrinogen to a cerebral hemorrhage. In 1940, Young and Medawar[25] used fibrin as a glue in microsurgery for peripheral nerve repair. In 1944, Tidrick and Warner[26] reported the first use of fibrin glue to secure human skin grafts. However, their products had suboptimal adhesive properties owing to the absence of fractionation technologies capable of providing concentrated fibrinogen. In the 1960s, Cohn fractionation led to the ability to generate highly concentrated fibrinogen preparations.[27] In 1972, Matras et al[28] introduced commercially available fibrin glue with a high fibrinogen content. Since then, refinements have added to the strength, efficacy, and safety of fibrin glues.

Fibrin glue is now a popular tool in many aspects of modern day surgery.[29-33] Fibrin adhesives are derived mainly from plasma components; most commercially available products contain purified, virally inactivated human fibrinogen and thrombin, with different quantities of factor XIII, bovine aprotinin, and calcium chloride. When fibrinogen and thrombin are mixed in the presence of calcium, fibrinogen is converted to fibrin. A fibrin polymer is formed that has a stable structure that facilitates the growth of collagen-producing fibroblasts.[34] Factor XIII is a fibrin-stabilizing factor, and aprotinin is an antiplasmin that protects the fibrin polymer clot from premature fibrinolysis.

Different investigators[16,18,25,35-39] have analyzed new alternatives to peripheral nerve anastomosis for optimizing nerve regeneration. Among these, cyanoacrylate synthetic glue should be mentioned, because it is easy to use, maintains the anastomosis even while under tension, and avoids all risk of viral transmission.[40-42] However, this adhesive has been criticized because of its toxicity, excessively slow resorption, and induction of an inflammatory reaction in perineural tissues.[43,44] Therefore, it is not recommended for nerve anastomosis.[45] Laser welding was also used for nerve repair, and its efficacy was similar to that of epineural suturing in some studies,[38,39] but inferior to it in others.[46] Laser welding can provide a seal around the epineurium without the potential of introducing a foreign material into the underlying fascicular structure. In contrast, the thermal effects of laser-assisted nerve repair can result in the destruction of myelin and the loss of axons immediately adjacent to the anastomosis site. Thus, although laser welding will not produce foreign body reactions, its tissue destruction could lead to fibrous tissue formation, which could be as detrimental to axonal growth as that induced by retained suture material. The results of our study are consistent with the results of several earlier studies.[16,18,46-49] Júnior et al[48] reported that axonal growth after epineural suturing was significantly faster and greater than after anastomosis with fibrin adhesives; however, the NCV was similar for both techniques. In our study, the histologic evaluation showed good axonal regeneration across the anastomotic site with no difference in the outcome of nerve regeneration between epineural suturing and fibrin gluing. This was also confirmed by other investigators.[18,22] Feldman et al[18] reported that the amounts of anastomotic perineural fibrosis, axonal regeneration, and alignment of axons were superior with the fibrin adhesive technique compared with epineural suturing.

Some investigators have reported that fibrin glue does not have sufficient tensile strength to hold a peripheral nerve repair and might produce stricture at the anastomosis site.[12] However, we did not see any case of anastomotic failure at the end of the follow-up period (16 weeks), and the 2 techniques (suture and fibrin glue) were equally adequate to stabilize the reanastomosed nerves during regeneration. The commercially available fibrin adhesives are of human origin; thus, there might be a potential risk of viral transmission. This can be minimized by the use of donor selection, screening, and viral inactivation. Autologous fibrin adhesives provide an attractive option because of the absence of a viral transmission risk. However, this technique is time-consuming (the process requires about 60 to 90 minutes for preparation) and requires extensive equipment.

Most of the earlier studies of peripheral nerve repair were on small animals (rats, rabbits, and so forth). However, we chose to use dogs in our study because the nerve size and number of nerve fibers in each nerve are more similar to those of humans. In the present study, the evaluation of nerve repair was done electrophysiologically and histologically. The follow-up period was 16 weeks, which is sufficient for nerve repair. The number of dogs included in the present study was not large enough for significant conclusions to be made.

From our results, we can conclude that epineural suturing and fibrin adhesives are equally alternative techniques in microsurgery repair of the transected nerves. Although financial considerations should be considered, fibrin glue could be advantageous to achieve nerve approximation in confined anatomic locations in which suture application is difficult or impossible for technical reasons.

Acknowledgment

The authors are thankful to Applied Physiology Research Center of Isfahan University of Medical Sciences, where the electrophysiologic testing was done.

References

1. Queral-Godoy E, Valmased-Castellon E, Berini-Aytes L, et al: Incidence and evaluation of inferior alveolar nerve lesions following lower third molar extraction. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 6:1, 2004
2. Kraut RA, Chahal O: Management of patients with trigeminal nerve injuries after mandibular implant placement. J Am Dent Assoc 133:1351, 2002
3. Pogrel MA: The results of microneurosurgery of the inferior alveolar and lingual nerve. J Oral Maxillofac Surg 60:485, 2002
4. Robinson PP, Loescher AR, Smith KG: A prospective, quantitative study on the clinical outcome of lingual nerve repair. Br J Oral Maxillofac Surg 38:255, 2000
5. Piñeros-Fernández A, Rodeheaver PF, Rodeheaver GT: Octyl 2-cyanoacrylate for repair of peripheral nerve. Ann Plast Surg 55:188, 2005
6. Landegren T, Risling M, Brage A, et al: Long-term results of peripheral nerve repair: A comparison of nerve anastomosis with ethyl-cyanoacrylate and epineural sutures. Scand J Plast Reconstr Surg Hand Surg 40:65, 2006
7. Aubá C, Hontanilla B, Arcocha J, et al: Peripheral nerve regeneration through allografts compared with autografts in FK506-treated monkeys. J Neurosurg 105:602, 2006
8. Hwang K, Kim SG, Kim DJ, et al: Laser welding of rat's facial nerve. J Craniofac Surg 16:1102, 2005
9. Terris DJ, Fee WE: Current issues in nerve repair. Arch Otolaryngol Head Neck Surg 119:725, 1993
10. Urbaniak JR: Fascicular nerve suture. Clin Orthop 163:57, 1982
11. Parker G, Write T, Jenkins R: Jenkins: Surgical repair of extratemporal facial nerve: A comparison of suture repair and microfibrillar collagen repair. Laryngoscope 94:950, 1984
12. Nishihira S, McCaffrey TV: Repair of motor nerve defects: Comparison of suture and fibrin adhesive techniques. Otolaryngol Head Neck Surg 100:17, 1989
13. Javelet J, Torabinejad M, Danforth R: Isobutyl cyanoacrylate: A clinical and histologic comparison with sutures in closing mucosal incisions in monkeys. Oral Surg Oral Med Oral Pathol 59:91, 1985
14. Toriumi DM, Raslan WF, Friedman M, et al: Histotoxicity of cyanoacrylate tissue adhesives. A comparative study. Arch Otolaryngol Head Neck Surg 116:546, 1985
15. Kuderna H: Clinical application of nerve-anastomoses adhesion using fibrinogen (in German). Fortschr Kiefer Gesichtschir 21:135, 1976
16. Berini-Aytés L, Sobré-Reche N: Sistema adhesiu de fibrina en la reparació del nervi facial. Protocol de model experimental en el nervi facial de conill. Barcelona, Spain, Facultat d'Odontología,Universitat de Barcelona, 1995
17. Becker CM, Gueuning CO, Graff GL: Sutures of fibrin glue for divided rat nerves: Schwann cell and muscle metabolism. J Reconstr Microsurg 1:139, 1984
18. Feldman MD, Staloff RT, Epsteinn G, et al: Autologous fibrin tissue adhesive for peripheral nerve anastomosis. Arch Otolaryngol Head Neck Surg 113:963, 1987
19. Millesi H: Peripheral nerve surgery today: Turning point or continuous development? J Hand Surg Br 15:281, 1990
20. Smahel J, Meyer VE, Bachem U: Gluing of peripheral nerves with fibrin experimental studies. J Reconstr Microsurg 3:211, 1987
21. Narakas A: The use of fibrin glue in repair of peripheral nerves. Orthop Clin North Am 19:187, 1988
22. Suri A, Mehta VS, Sarkar C: Microneural anastomosis with fibrin glue: An experimental study. Neurol India 50:23, 2002
23. Bergel S: Uber Wirkungen des Fibrins. Dtsch Med Wochenschr 35:663, 1909
24. Grey E: Fibrin as a haemostatic in cerebral surgery. Surg Gynecol Obstet 21:452, 1915
25. Young JZ, Medawar PB: Fibrin suture of peripheral nerves. Lancet 1:126, 1940
26. Tidrick RT, Warner ED: Fibrin fixation of skin transplants. Surgery 15:90, 1944
27. Alving BM, Weinstein MJ, Finlayson JS, et al: Fibrin sealant: Summary of a conference on characteristics and clinical uses. Transfusion 35:783, 1995
28. Matras H, Dinges HP, Lassman J, et al: Zur Nahtlosen interfaszikularen nerventransplantation in tier experiment. Wien Med Wochenschr 122:517, 1972
29. Petersen JK: Clinical experience in oral surgery with human fibrin sealant. Int Dent J 35:277, 1985
30. Nomori H, Horio H, Suemasu K: Mixing collagen with fibrin glue to strengthen the sealing effect for pulmonary air leakage. Ann Thorac Surg 70:1666, 2000
31. Canby-Hagino ED, Morey AF, Jatoi I, et al: Fibrin sealant treatment of splenic injury during open and laparoscopic left radical nephrectomy. J Urol 164:2004, 2000
32. Czerny M, Verrel F, Weber H, et al: Collagen patch coated with fibrin glue components: Treatment of suture hole bleedings in vascular reconstruction. J Cardiovasc Surg (Torino) 41:553, 2000
33. Siedentop KH, O'Grady K, Park JJ, et al: Fibrin sealant for treatment of cerebrospinal fluid leaks. Am J Otolaryngol 20: 777, 1999
34. Michel D, Harmand MF: Fibrin seal in wound healing: Effect of thrombin and [Ca2+] on human skin fibroblast growth and collagen production. J Dermatol Sci 1:325, 1990
35. Collins JA, Pani KC, Lehman RA, et al: Biological substrates and cure rates of cyanoacrylate tissue adhesives. Arch Surg 93:428, 1966
36. Kline DG, Hayes GJ: An experimental evaluation of the effect of a plastic adhesive, methyl 2-cyanoacrylate, on neural tissue. J Neurosurg 20:647, 1963
37. Matsumoto T, Hardaway RM, Heisterkamp CA, et al: Higher homologous cyanoacrylate tissue adhesives in surgery of internal organs. Arch Surg 94:861, 1967
38. Curtis NJ, Lauto A, Trickett R, et al: Preliminary study of microsurgical repairs of the inferior alveolar nerve in rats using primary suturing and laser weld techniques. Int J Oral Maxillofac Surg 27:476, 1998
39. Eppley BL, Kalenderian E, Winkelmann T, et al: Facial nerve graft repair: Suture versus laser-assisted anastomosis. Int J Oral Maxillofac Surg 18:50, 1989
40. Choi BH, Kim BY, Huh JY, Lee SH, Zhu SJ, et al: Microneural anastomosis using cyanoacrylate adhesives. Int J Oral Maxillofac Surg 33:777, 2004
41. Cai P, Liu GH, Hua QQ: Application of alpha-cyanoacrylate medical adhesive in fixation of intratemporal facial nerve within chitin chamber. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi 16:158, 2002

42. Teseng YC, Hyon SH, Ikada Y, et al: In vivo evaluation of 2-cyanoacrylates as surgical adhesives. J Appl Biomater 1:111, 1990
43. Wieken K, Angioi-Duprez K, Lim A, et al: Nerve anastomosis with glue: Comparative histologic study of fibrin and cyanoacrylate glue. J Reconstr Microsurg 19:17, 2003
44. Montanaro L, Arciola CR, Cenni E, et al: Cytotoxicity, blood compatibility and antimicrobial activity of two cyanoacrylate glues for surgical use. Biomaterials 22:59, 2001
45. Jin Y, Dehesdin D, Hemet J, et al: Étude expérimentale comparative des reparations nerveuses par suture classique ou par colle biologique. Neuro Chir 36:378, 1990
46. Sarlak AY, Can C, Yüce E, et al: Comparative study of microepineural suture, microepineural suture-aided CO_2 laser, and laser-only anastomoses in rat sciatic nerves. J Clin Laser Med Surg 12:273, 1994
47. Merle M, Becker C, Pankovic C, et al: La reparation microchirurgicale des nerfs periphériques et des vaisseaux par le tissucol: Clinique et experimentale. Rev Laryngol Otol Rhinol (Bord) 108:13, 1987
48. Júnior ED, Valmaseda-Castellón E, Gay-Escoda C: Facial nerve repair with epineural suture and anastomosis using fibrin adhesive: An experimental study in the rabbit. J Oral Maxillofac Surg 62:1524, 2004
49. Pogrel MA, Thamby S: The etiology of altered sensation in the inferior alveolar, lingual, and mental nerve as a result of dental treatment. J Calif Dent Assoc 27:531, 1999