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Новый метод укорочения длины нервного трансплантата и восстановления нерва (опыт оперативного лечения 30 случаев акушерского паралича плечевого сплетения)

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A New Method to Shorten the Length of Nerve Graft and to Secure the Nerve Repair (an intraoperative experience based on 30 cases of Obstetrical Brachial Plexus Palsy)

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Цель: сравнить результаты применения стягивающего шва для перекрытия диастазов нервных стволов с лечением без использования шва, для сопоставления влияния двух способов на длину трансплантата, количество трансплантатов и количество нервных стволов в каждом трансплантате. *Методы*: сравнительное исследование двух групп младенцев с акушерским параличом плечевого сплетения (OBPP), по 15 младенцев в каждой группе. Всем пациентам обеих групп было показано иссечение невромы и трансплантация нервов. В группе А дефекты замеряли непосредственно после иссечения невромы, не пытаясь сблизить концы нервов, после чего проводилась реконструкция ствола нерва трансплантатами из икроножных нервов с применением фибринового клея. И, наоборот, в группе В мы измеряли дефекты после наложения через задний участок эпиневрия одного или двух перекрывающих стягивающих швов с целью устранения образованного промежутка, не прикладывая напрягающих усилий. После этого также проводилась реконструкция ствола нерва трансплантатами с применением фибринового клея. *Результаты*: в группе В длину трансплантатов для пластики ствола нерва возможно уменьшить с 29,6 мм до 14,2 мм, в среднем, на 15,4 мм. Количество стволов в составе трансплантата возрастает с 2,2 до 3,2. Количество трансплантатов, использованных при реконструкции плечевого сплетения, было больше в группе В, чем в группе А. *Выводы*: простой перекрывающий стягивающий шов может предотвратить ретракцию концов нервов после лечения с применением фибринового клея, он выполняет роль внутреннего шинирования на уровне повреждения, позволяя уменьшить длину трансплантата ствола нерва, увеличить число стволов в составе трансплантата, и обеспечивает возможность для использования большего количества нервных трансплантатов, повышая уверенность хирурга в надежности лечения.
Ключевые слова: родовой паралич, плечевое сплетение, фибриновый клей, акушерский паралич, периферический нерв, стягивающий шов.

Purpose: to compare the result of using a stay stitch to bridge the nerve gaps with repair the nerve gap without using a stay stitch, to compare both ways on the length of graft, number of grafts and number of cables per graft. *Methods*: a comparative study between 2 groups of babies with OBPP in which each group consists of 15 infants. In all the patients in both groups, neuroma excision and nerve grafting was indicated. In group (A) the defects were measured directly after neuroma excision without any attempts to approximate the retracted ends of the nerves, this was followed by reconstruction of the gaps by cable grafts from the sural nerves using fibrin glue. Conversely, in group (B) we took measurements of the defects after using 1 or 2 bridging stay sutures through the posterior aspect of the epineurium just to overcome the retracted distance without any further tension on the nerve. This also was followed by reconstruction of the gaps by cable nerve grafts with the aid of fibrin glue. *Results*: in group (B), the cable grafts length can be shortened from (29.6mm to 14.2 mm) with average of (15.4 mm). The number of cables per graft increase from 2.2 to 3.2. The number of grafts used in reconstruction of the brachial plexus were more in group B than in group A. *Conclusions*: A simple bridging stay suture can prevent retraction of the nerve ends after repair with fibrin glue, working as an internal splintage to the repair site, decrease the length of the cable graft, increase the number of cables per graft, gives more opportunity to make more nerve grafts and the surgeon feel that his repair is more secure.
Keywords: birth palsy, brachial plexus, Fibrin Glue ,obstetrical palsy, peripheral nerve, stay stitch.

INTRODUCTION

In exploring the elements of the Brachial plexus, the surgical techniques can be separated into neurolysis, direct repair, nerve grafting, and nerve transfers. Direct repair is not possible after birth palsy because the stretching mechanism of injury results in a large neuroma that prohibits coaptation after resection.

The role of neurolysis has been carefully and thoroughly assessed. Clarke et al [1, 2], reported better long-term results after resection and grafting of both conducting and nonconducting neuromas compared with neurolysis, despite an initial deterioration of function with resection. This evidence negates any neurolysis in the treatment plan. Neuroma resection and nerve grafting is currently the gold standard treatment [3, 4, 5].

The most optimal technique of nerve grafting is the autogenous graft which is a nerve harvested from another region within the injured person's body [6]. The limited number of donor nerves and the necrosis of the graft in case of large grafts are commonly encountered problems. Moreover, in animal studies it has been found that repair with fibrin glue alone resulted in an 80 % dehiscence rate [7].

These two facts have grabbed our attention to the idea of our bridging stay suture, which has shown (from our study) to be efficient to shorten the nerve gap length and subsequently the graft length.

PATIENTS AND METHODS

Between May 2007 and October 2009, our comparative study was conducted. Thirty patients with OBPP underwent brachial plexus exploration and reconstruction including neuroma excision and nerve grafting. Patients included 19 females and 11 males, all of them were delivered vaginally. The palsy involved the right side in 17 cases and the left side in 13 cases. The average age of surgery was 5.7 months (range 3-14 month). Clinically 10 cases had upper trunk injury, 4 had upper and middle trunks injury and 16 had total palsy.

Group (A) included 15 patients (46 grafts) where the brachial plexus was reconstructed by cable nerve grafts without the use of the bridging stay suture. Group (B) also included 15 patients (56 grafts) where the plexuses were reconstructed with cable nerve grafts too yet, after approximation of the 2 ends by the bridging stay suture.

Surgical techniques:

Regarding group (A)

The baby is put on his back with his face turned to the opposite side of the lesion. A small cushion is used under the shoulders to make the neck extended and the head is supported by an underlying head ring. We used a V-shaped incision for exposure of the posterior triangle, the incision follows the posterior border of the sternoclidomastoid, makes a gentle curve just above the clavicle, then follows a line parallel to the clavicle. On occasions, we need to extend the incision along the deltopectoral groove for exposure of the more distal plexus if lower lesions were encountered.

If the decision is to resect neuroma with nerve graft (which was the case in all our patients), after neuroma resection the proximal root is evaluated(satisfactory source of nerve fibers suitable for grafting). Gross examination of the root involved and intraoperative muscle response to direct nerve stimulation (long thoracic nerve and nerve to rhomboids), the concentration is directed to the distal element of the plexus according to the extent of the neuroma. The gap created after neuroma resection is then ready to be bridged with nerve graft to established nerve continuity. By now, the second team has already harvested the sural nerve bilaterally, the support along the back is then removed also the head is turned to midline direction and small towel is put under the shoulder, by that time a precise measurements of the gaps between different elements of the plexus (proximal and distal), and according to the plan of reconstruction is done with a soft ruler.

The cable grafts are prepared precisely on a hard object according to previous measurements and secured together with a few drops of Fibrin Glue. A soft plastic background is placed under the plexus extending well under both proximal and distal elements. Eventually, the prepared cable graft transferred and placed in position, the graft is then secured in place with Fibrin Glue. The wound is closed in layers. The baby is put in plaster cast (hemispica with an overhead halo) with the face turned towards the site of surgery to prevent widening of the cervico axillary angle and promotes immobilization of the repair site.

Regarding group (B)

From our experience with patients in group (A) we noticed that there was usually an over estimation to the length of the gap after neuroma resection. This fact was due to the natural nerve retraction after the excision of the neuroma (fig. 1).

We felt that shorter cables could have been used if we had overcome this retraction. Accordingly, in patients in group (B) the same steps were done, yet prior to measuring the gap length we used 1 or 2 simple bridging stay sutures between the proximal and the distal elements of the plexus through the posterior epineurium about 2 mm from the cut surface using 8/0 nylon sutures (fig. 2).

Putting in mind that tension on the nerve endings can lead to ischemia, dehiscence and graft failure, we avoided tension by compensation of only the retracted distance while tying the suture. Moreover a bleeding cut surface was a good indicator in many cases of tensionless repair. After securing the sutures accurate measurements of the gaps were taken. Accordingly the prepared cable grafts transferred and placed in position, then the grafts were secured by fibrin glue (fig. 3-5).

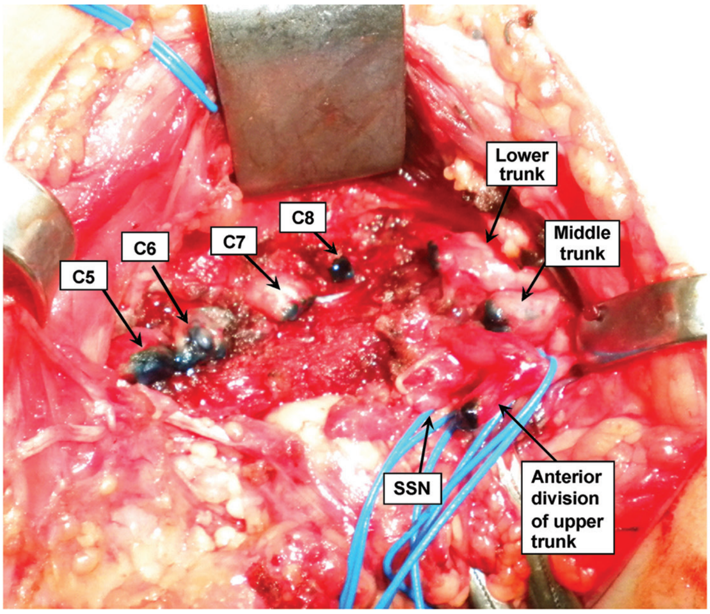

Fig. 1. Neuroma has been excised and both proximal and distal components of the plexus prepared and marked with methylene blue. The length of the gap ranges from 30-40 mm

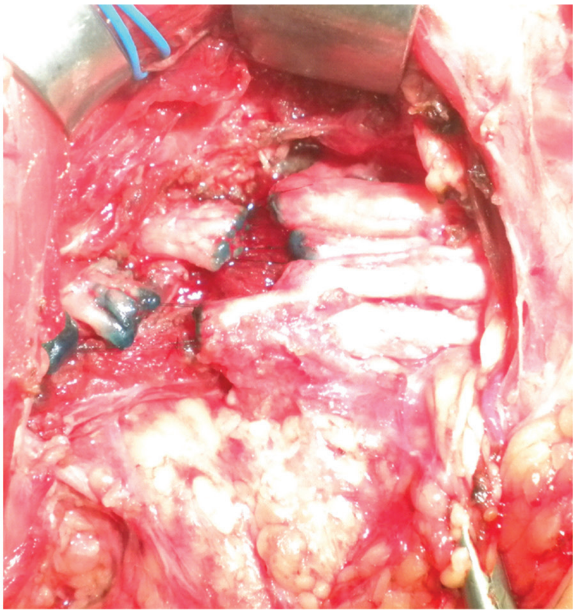

Fig. 2. Stitches are taken the length of the gap decrease to be between 10-20 mm

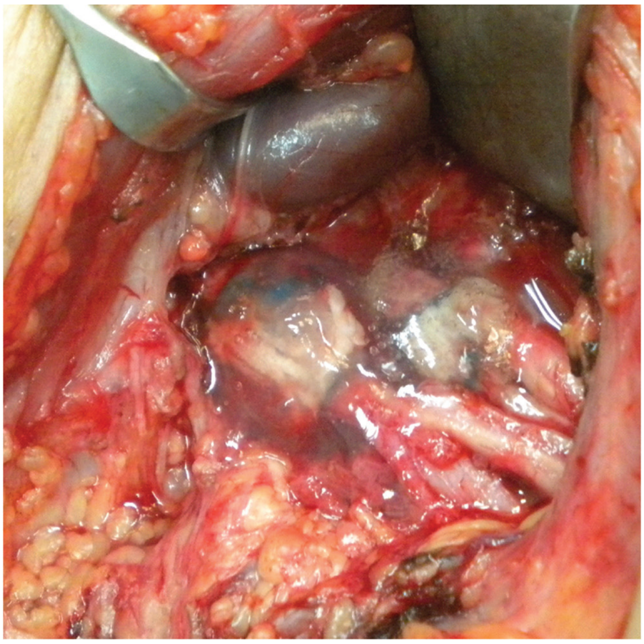

Fig. 3. Grafts are positioned in place and glued with Fibren Glue

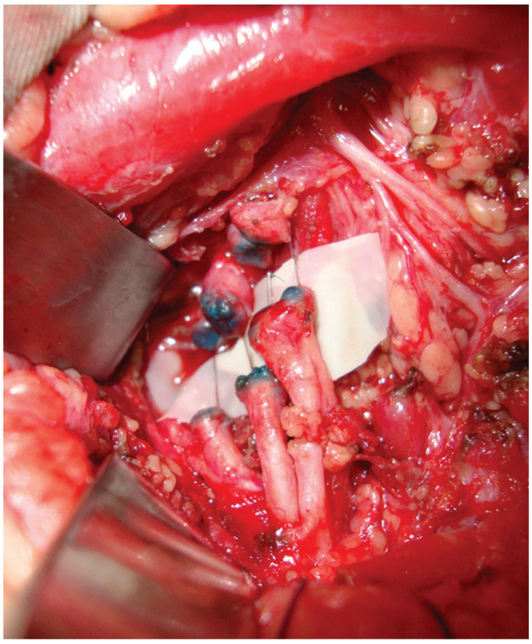

Fig. 4. After neuroma excision and trimming of the proximal and distal components of the plexus, a series of 8-0 Ethilon stitches were taken to approximate both ends, minimizing the distance to only few millimeters

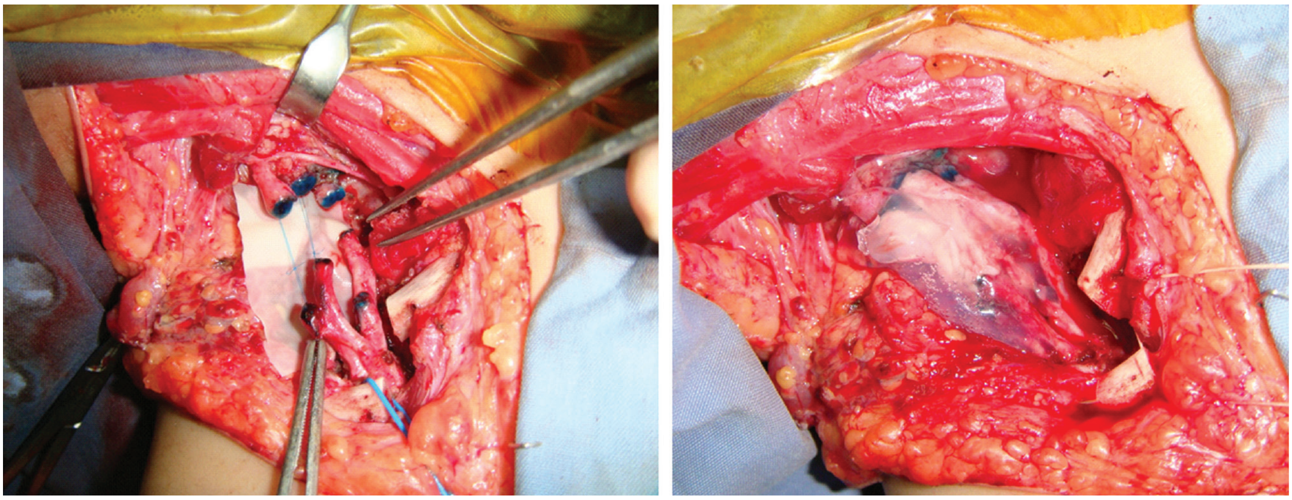

Fig. 5. Stitches were taken, distance greatly reduced and cable grafts secured in place with Fibrin Glue only

In both groups data regarding the site of the lesion, the number of grafts, number of cables and length of individual cables were documented and shown in (tables 1, 2).

Table 1

Group A patients, in which nerve repair without a stay suture

Patient Age (months)	Site of the lesion	Number of grafts	Numder of cables/graft				Lengthof cable (mm)				Doner sites
5	UT	2	3	3			35	37			2 surals
6	UT	2	3	3			32	25			2 surals
4	UT	3	1	2	3		25	27	35		2 surals
6	UT	2	3	3			29	32			2 surals
4	UT	3	1	3	2		25	33	31		2 surals and cervical cutaneous nerves
6	UT and MT	3	2	3	2		26	28	28		2 surals
4	UT and MT	4	2	2	3	1	30	25	25	30	2 surals and cervical cutaneous nerves
4	Total	4	2	2	1	3	25	25	32	30	2 surals and cervical cutaneous nerves
5	Total	4	2	2	2	2	20	25	30	29	2 surals and cervical cutaneous nerves
10	Total	3	2	2	3		24	36	30		2 surals
11	Total	3	2	2	3		36	27	25		2 surals and cervical cutaneous nerves
8	Total	3	2	2	3		30	27	25		2 surals
4	Total	4	1	2	2	2	35	25	26	21	2 surals and cervical cutaneous nerves
6	Total	3	2	2	2		37	32	31		2 surals and cervical cutaneous nerves
3	Total	3	2	2	2		38	31	34		2 surals and cervical cutaneous nerves

Table 2

Group B in which a stay suture was used to bridge the nerve gap

Patient Age (months)	Site of the lesion	Number of grafts	Numder of cables/graft					Lengthof cable (mm)					Doner sites
3	UT	3	4	4	4			20	20	18			2 surals
5	UT	3	4	4	4			15	12	20			2 surals
6	UT	2	4	5				13	20				2 surals
4	UT	3	3	4	4			10	13	12			1 sural and cervical cutaneous
5	UT	3	3	3	3			11	9	10	15		2 surals
6	UT AND MT	4	3	3	4	3		15	16	13			2 surals
5	UT AND MT	4	3	3	3	3		16	12	11	10		2 surals
8	TOTAL	4	3	3	3	3		20	13	15	16		2 surals
9	TOTAL	4	3	3	3	3		12	17	7	11		2 surals
10	TOTAL	4	3	3	3	3		20	15	13	15		2 surals
3	TOTAL	5	3	3	2	3	2	12	15	17	10	20	2 surals
5	TOTAL	4	3	2	3	2		15	8	17	20		2 surals
6	TOTAL	4	3	3	3	2		16	12	10	15		2 surals
4	TOTAL	5	2	2	3	3	2	13	14	5	15	20	2 surals
3	TOTAL	4	3	3	3	4		10	10	12	17		2 surals

RESULTS

In group B there is a significant decrease in the length of the cable nerve grafts, from 29.5 mm in group A to an average of 14.2 mm in group B, about 50 % decrease in cable length, which theoretically should end with more favorable clinical results. The decrease in the length of cable nerve grafts resulted in increase of number of cables per nerve graft, from average of 2.2 to 3.2 cables in each graft, we feel that the increase in number of cable may end with more favorable clinical results too. The number of grafts used in reconstruction of the brachial plexus were more in group B than in group A. This is due to availability of more length in the graft after shorten the gap length. So we didn't have to sacrifice some of the nerves in reconstruction as was done in many cases of group A. Figures 6, 7 show the average numbers of nerve grafts, cables and length of cables in group A and B. Simply there is no statistical significant difference in age between the two groups. There are statistical significant difference in number of grafts, number of cables and length of cables, group A had less number of grafts, less number of cables but the average length of the cables was higher.

We didn't find significant difference in the age distribution between the two groups. It's early to assess the final clinical outcome in both groups. If we found favorable clinical results in group B, this method should be an excellent step in the operative exploration of OBPP cases.

The size of the neuroma was not considered in this comparative study, because we used to excise the center of the neuroma at first, then we need to cut more till we see normal fascicles in both proximal and distal ends. Usually the neuroma was 3 or more pieces and it was difficult to have an accurate measurements.

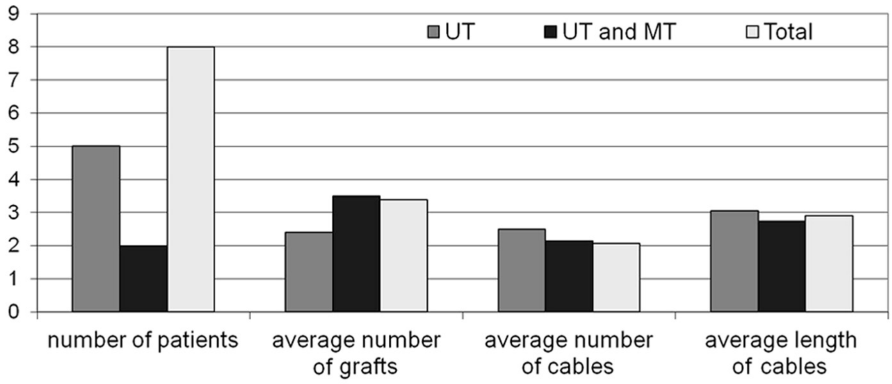

Fig. 6. Shows average numbers of grafts,cables and length of cables in group A

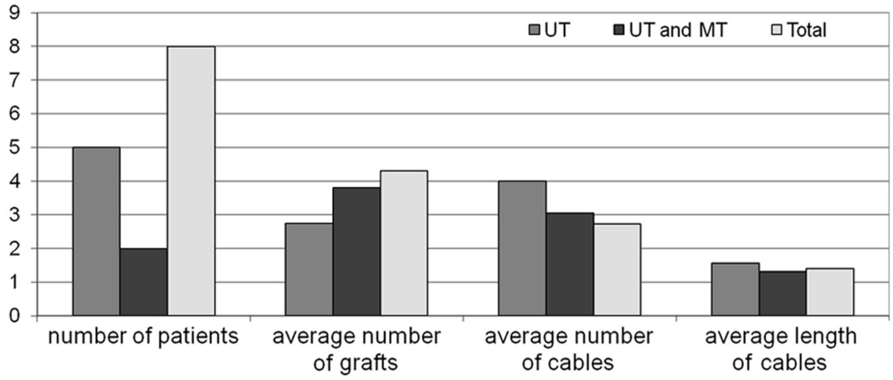

Fig. 7. Shows average numbers of grafts, cables and length of cables in group B

DISCUSSION

The reconstruction of long distance nerve injuries still represents a great challenge to any surgeon who is engaged in peripheral nerve surgery. The therapy of such injuries is hampered by the restricted availability of autologous nerves suitable for nerve grafting [8].

Although the sural nerve harvesting is pretty common in cases of brachial plexus reconstruction due to its relative long course, the material gathered from both sural nerves or even other additionally harvested autologous nerves is not sufficient to reconstruct extended lesions which represent the majority of cases. Other autologous nerves can help additionally but still are not sufficient in reconstruction of the complete brachial plexus. Consequently, the surgical treatment of such lesions is thus incomplete, favoring the reconstruction of only a few nerves (i.e. musculocutaneous nerve, median nerve) in order to stabilize the shoulder and to mobilize the elbow [9, 10, 11, 12]. In our comparative study, in group B because the gap length was shorter, the number of grafts were more; in some case we were able to reconstruct most of the nerves and so we were not obligated to sacrifice some nerve like the middle trunk.

Ruijs et al in his meta-analysis of predictors of motor and sensory recovery after nerve repair concluded that longer grafts are likely to give unfavourable results [13], also most authors consider the defect of more than 4 cm to be critical for obtaining good outcome after repair [14, 15, 16, 17]. Although the length of nerve grafts were less than 4 cm in both groups, but still we think the shorter the nerve graft may be the better. In group A, the average length was 29.5 mm and decrease to 14.2 mm in group B. We are not sure if this will have a significant impact on the clinical outcome.

Although considered a standard method in repairing peripheral nerve lesions, nylon thread suture may cause an inflammatory reaction that may affect the regeneration process [18] Martins et al [19] concluded that fibrin glue repair is the experimental method that has more advantages in regeneration after nerve section as compared with conventional suture repair. Such results have also demonstrated that use of the combined technique of a stitch and fibrin glue does not worsen regeneration as compared with the use of fibrin glue alone. In group B, the stitch we apply was 2 mm away from the repair site and through the epineurial tissue so not to cause any inflammatory reaction in the repair area, that may affect the regeneration. Fibrin glue was used on the repair in both groups.

Narakas reports better functional outcomes with fibrin glue than with suture repairs in human clinical trials [20]. Conversely, in animal studies it has been found that repair with fibrin glue alone resulted in an 80 % dehiscence rate, and when used in combination with sutures the glue increased the inflammatory reaction [21]. There has also been great interest in the use of laser tissue fusion or "welding" as a potential technique for nerve repair. A major limitation with laser welding is that the low-level thermal coagulation creates only weak bonds. This is reflected in the unacceptably high dehiscence rates (up to 41 %) found by some investigators [22, 23]. Efforts to enhance the bond strength have included the use of stay sutures, protein solders, and bands [24, 25]. Too additional tension on the repair site, increases the risk of dehiscence. Repairs under tension are also known to yield poorer functional recovery and diminished axon diameter [26].

Over the recent years, knowledge of the factors influencing a nerve reconstruction has increased, and also new surgical techniques and equipment have been developed. The nerve stumps tend to retract and primary suturing of the stumps is only possible when no tension is generated at the coaptation site [27]. The biomechanical properties of nerves are affected by injury. One recent study showed increased stiffness in the distal stump of rat sciatic nerves over a period of 5 weeks. Linear elastic stiffness reached a maximum at weeks 1 and 2 after transection, and nerves at those time points were 15 % stiffer than the contralateral control sides. The authors noted that significant stiffness developed in the distal segment of the nerve after only 1 week. This may lead to an increase in tension at the repair site as attempts are made to bring stiffer nerve ends together [28].

To feel more secure with the repair, a stay suture will give the surgeon this feeling. We couldn't know the dehiscence rate in the clinical situations, but it should be around zero to have an acceptable results. One of the causes of the poor results after microsurgical repair is dehiscence. Fibrin glue alone has a good adhesive property, but the retractile properties of the nerves may overcome the adhesive strength of the glue. Moreover, to secure the nerve repair, the kids were kept in complete spica including the head and the chest. We fine that, sometimes the kids were able to move their heads inside the spica, or the spica get damaged from soiling and poor hygiene. In these cases the stitch may act as an internal splintage to the repair site and decrease the incidence of dehiscence. To not damage the repair, we always take the stitch first then apply the fibrin glue.

In cases of brachial plexus surgery, the gap can be shorten by almost 1 cm or even more, if you only push the shoulder anterior and take your suture. This 1 cm in each graft can give you 9 cm extra length, if you use 3 cables for 3 nerve gaps, which is almost a total length of one sural nerve in 3 month old infant. Also the shorter the nerve graft the better results of surgery, and by that you can be more generous in trimming the nerve to reach the normal nerve tissue pre and post neuroma. This suture also assure you even if you have low quality fibrin glue that you buy from local hematological Lab.

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