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APPLICATION OF TETORON MESH-ADHESIVE TECHNIQUE IN NEUROSURGERY

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ABSTRACT

This report is to shcw the basic study—histological follow up—of my "cyanoacrylate monomer adhesive-polyflon coated tetoron mesh technique" which was advocated and applied in our neurosurgical practice for past 6 years in over 100 clinical cases.

This technique was adapted for clinical application with fairly brief experimental works at begining, since it was known these materials were not noxious and the amount of application was so little. This technique is useful especially in neurosurgical operation such as dura substitute transplantation in the cases of head injury, complete removal of dura infiltrating brain tumors, repair of cerebrospinal fluid leakage, repair of big dural venous sinuses and wrapping procedure of intracranial aneurysms.

For the experimental investigations, 50 mongrel adult dogs were used as experimental animals. The tetoron mesh was transplanted to patch the experimentally produced dural deficit and broken dural venous sinus. Grossly, this technique seems to be satisfactory for the repair of these.

Histological study of the grafts, taken after 10-180 post-operative days, reveals gradual absorption of cyanoacrylate glue and apparently the glue was phagocytosed and emigrated away as the intracellular deposit of giant cells. As the matters of fact, many cases showed no evidence or even a trace of this glue in careful dissection.

Healing process of grafted region is made without excess granulomatous tissue, but proper formation of neomembrane over the graft. Conclusively, this technique seems more preferable than any other reported procedures.

Medical uses of adhesive have become popular by the development of cyanoacrylate monomer such as Eastman 910 and cyanobond, etc. Since 1962, the present author have been utilizing surgical adhesives made in Japan in neurosugical operations, and over one hundred clinical cases have been examined. The surgical operations have always been successful without any side effect.

Surgical application of high molecular adhesives could be classified in two groups: (1) Direct method: The separated tissues are connected and fixed with glue between two incised surfaces with expectation that the healing

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process will progress through the surgical glue. However, if excess amount of glue is applied, the healing granulation tissues would not connect the separated each tissue because of the septal wall action of the fixative glue. The tissue-connection may be obtained in a week or ten days after the application of adhesives, but thereafter, the applied glue acts as a foreign body and rejected by healing process of the tissue. The wound once fixed to it will be separated again and resulted in the insufficient wound closure, so this method can not be used in the closure of deep structure but rather effective for wounds of layers of the skin. (2) Indirect method: This is called also wrapping method because two separated wound surface are connected directly, and the conjugation point is fixed by wrapping with surgical adhesives. In this method, normal healing process of granulation can be expected, and new blood vessel formation was observed between two connected tissues. In the field of neurosurgical operation, the latter technique is thought to be more practical especially in those cases in which the sewing technique is difficult or impossible to perform.

In the past 6 years, studies were made to make better dural substitute. It was found that the tetoron mesh is most preferable when it is coated with polyflon media. This mesh is 0.2 mm in thickness and is of fine texture to permit 7.5 ml/cm^2 air flow through it. The substitute which we developed has much less side effects of adhesion compared to those previously used as dural substitute. In the beginning of this study, surgical adhesive was used for transplantion of the tetoron mesh to cover the dural defect after complete removal of the meningioma. It was found that this method made a complete and satisfactory patch of dura mater, and later this substitute was applied on the basal skull fracture to shut the leakge of cerebro-spinal fluid. Furthermore, bleeding of the broken dural venous sinus was controlled with satisfactory patch of the wall of the sinus vein. Therefore, I believe that the tetoron mesh surgical adhesive technique will become one of the fundamental surgical techniques.

MATERILS

At present, there are several surgical adhesives available for the practical use, and in the present study, alpha-cyanoacrylate monomer (alon alpha) synthesized by TOA Chemical Company of Nagoya, Japan, was used for surgical adhesive. There are two kinds of alpha-cyanoacrylate, CS-215-1 and CS-215-2. The former has a more rapid polymerization mechanism and is of thicker viscosity. It is suitable for application on the skin or dry area. In neurosurgical technique, which always has a wet field, the latter compound should be used. This has rather thinner viscosity and its polymerization is rather slow, and the necessary amount of application is much less. The chemical mechanism of these adhesives is due to polymerization. The adhesion tension

TABLE 1. Aron·Alpha (alpha-cyanoacrylate)

	monomer	polymer
	CN | $n(CH_2{=}C{-}COOCH_3)$	CN | $(-CH_2{-}C{-}COOCH_3)n$
Viscosity	#201 2 cps #202 40 cps	
Specific gravity	1.04	1.25
	flash point 82°C	melting point 155–158°C

is very strong; it has 411 kg/cm^2 tension in between copper material at 60°C. The polymerization reaction of adhesion is also rapid, usually it requires 10–20 seconds at 20°C. Between two tetoron meshes, adhesion tension is measured 1.5 kg/cm^2 after 5 minutes, and it has more flexibility than that of Eastman 910. It may be kept stable for 6 months at room temperature, more than 1 year at 10°C, and almost permanently if it is kept at 0°C.

Description of our tetoron mesh was made previously as one of the ideal dural substitute. In order to make artificial sagittal sinus vein, thicker texture of tetoron is used to make section which should be adjusted in a triangular shape to fit close to the shape of the sagittal sinus section. For this purpose, silicon coated tetoron mesh is necessary to prevent clotting of the venous blood.

ANIMAL EXPERIMENTS

Fifty adult mongrel dogs were used in the study of chronic experiment to follow the changes of tetoron mesh and surgical adhesives after transplantation *in vivo*. Furthermore, transplantation of artificial sagittal sinus vein was tried to anastomose dural vein as well as to repair excised wall of dural sinus with this technique.

Under the intraperitoneal barbiturate anesthesia, the craniotomy was carried out with aseptic technique. A dural defect about 1.5 cm in diameter was made, and then this was patched with tetoron mesh and adhesive. At the same time, in some of the animals, brain surface of the dural defect was intentionally injured by experimental cortical excision, and in other experiments, dural patch was made with sewing technique as control. In three experiments, intentional infection was made in the craniotomy field, and the animals were given intensive antibiotics treatment afterwards to see the changes in such condition.

The experiment of repair of the sagittal sinus was made with excision of a part of the wall of the sinus rather than just tearing of the wall of the sinus vein. Both ends were clamped with vascular clamps, and then the tetoron mesh was patched with surgical glue. Transplantation of artificial sinus is still rather difficult technically because of clotting after the transplantation, partly due to the small size of dog's venous sinus.

In 31 experiments, the bone flap was not replaced for later convenience of histological investigation; the bone flap could be readily separated from transplanted mesh graft in the cases with bone flap replacement. Therefore, in the latter half of this series the bone flap replacement was not made. Temporal muscle showed no remarkable adhesion onto the tetoron mesh, too.

All experiments were successful including the infected cases, and all dogs survived untill sacrificed.

The animal experiments are classified as follows:

(A) Dural patch with adhesive only — 18 cases.
(B) Dural patch with adhesive with artficial injury to the brain surface — 10 cases.
(C) Dural patch with silk suture only — 9 cases.
(D) Dural patch with silk suture with artificial injury to brain surface. — 7 cases.
(E) Hemostasis and patch of dural venous sinus using dural patch with adhesive technique — 6 cases.

The results of the animal experiments are summerized as follows:

No.	Type of experiment	Survival days	Adhesion		Bone Flap replacement	Infection
			Defect	Sutured		
1	A	120	(−)		(+)	
2	A	150	(−)		(+)	
3	A	120	(±)		(+)	
4	A	150	(−)		(+)	
5	A	130	(−)		(+)	
6	A	180	(−)		(+)	
7	A	130	(−)		(+)	
8	A	30	(±)		(+)	
9	B	150	(++)		(+)	
10	B	90	(+)		(+)	
11	B	20	(+)		(+)	
12	B	30	(++)		(+)	(+)
13	C	150	(±)	(±)	(+)	
14	C	120	(−)	(±)	(+)	
15	C	90	(−)	(±)	(+)	
16	C	120	(±)	(+)	(+)	
17	D	150	(+++)	(+)	(+)	(+)
18	D	60	(++)	(±)	(−)	
19	D	120	(++)	(±)	(+)	
20	D	90	(++)	(+)	(+)	
21	B	120	(++)		(−)	
22	B	120	(+)		(−)	
23	A	90	(−)		(−)	
24	A	90	(−)		(−)	
25	A	60	(−)		(−)	
26	A	60	(±)		(−)	
27	C	60	(±)	(±)	(−)	
28	C	60	(±)	(+)	(−)	
29	B	60	(+)		(−)	
30	B	60	(+)		(−)	

(*Continued*)

No.	Type of experiment	Survival days	Adhesion		Bone flap replacement	Infection
			Defect	Sutured		
31	B	90	(++)		(−)	
32	A	10	(−)		(−)	
33	C	30	(−)	(±)	(−)	
34	D	30	(++)	(+)	(−)	
35	C	20	(−)	(+)	(−)	
36	A	10	(−)		(−)	
37	A	20	(−)		(−)	
38	A	20	(±)		(−)	
39	A	30	(−)		(−)	
40	A	30	(−)		(−)	(+)
41	B	10	(+)		(−)	
42	C	10	(−)	(±)	(−)	
43	D	20	(+)	(±)	(−)	
44	D	10	(+)	(+)	(−)	
45	E	30			(−)	
46	E	30			(−(	
47	E	20			(−)	
48	E	20			(−)	
49	E	10			(−)	
50	E	50			(−)	

RESULTS

Histological changes are summerized as follows:

1) The adhesion of cerebral cortex were remarkable in 12 cases out of 16 sutured experiments. On the contrary, in techniques using adhesives, 8 cases out of 28 experiments were found with cortical adhesion.

As to adhesion between mesh and cortical surface of brain, it was seen more often among the cases of cortical injury. Among 27 dogs without the injury of brain surface, fibrous adhesion was noted in 5 cases, while among 17 dogs with intentinal cortical injury, all showed the adhesion between graft and brain surface from mild to moderate extent such as stringlike fibrous tissue formation or localized adhesion. I assume that 5 dogs showed fibrous adhesion was resulted by unintentional mild injury over the brain surface during the experiment.

These cortical adhesion were observed more marked in the group of dural graft with sewing technique rather than those of surgical adhesives. Adhesion surrounding the sewed area was seen in 7 among 16 dogs. Generally, the minor injury over the brain tissue during sewing surgery is difficult to avoid.

In 3 infected cases, 2 dogs showed intentional cortical injury and cortical adhesion was observed as expected, but one of the dogs without cortical injury revealed infection only out side of dura mater. No intradural infection or cortical adhesion was observed.

2) In the experiments with 1.5 cm width patch, the tetoron mesh was covered by thin fibrinous neomembrane within 10 days and round cell infiltrations

were observed in moderate dergee. It is intersting to note that outer surface of the tetoron mesh is covered by much thicker neomembrane and subarachnoid space shows engorgement of blood vessels without evidence of extravasculation or remarkable hemorrhage. No noticeable change was observed over the cortical surface of the brain. One month later, the infiltration was reduced. By 2-3 months, small meningeal vessels was developed, but the inner surface showed much less thickness of neomembrane which readily showed the structure of the texture mesh to make very smooth and thin lining. This could be analysed that the outer membrane has characteristics of periosteum of dura mater as well as the inner membrane as the inner lining of the covering membrane. This finding is always true and beautifully observed especially in clinical cases which is mentioned later.

3) By one month later, the reduction and emigration of the adhesive materials were already noted and adhesives disappeared in 3 months. Adhesives were usually not observed in the grafted area 6 months later, and newly developed granulations took the place of it. Thereafter, surgical adhesive itself was taken away gradually by phagocytosis. In this technique, however, it should be emphasized to use minimum and only necessary amount of glue, so in most animal experiment, it was difficult to find, even a trace of glue at the time of sacrificing of the animal. If an excess amount of glue was used, solid foreign body masses could be found in the surgical areas.

4) Tetoron patch applied to the dural sinus reveals essentially the same histological changes. Although no occlusions of the vascular canal were observed, the tetoron mesh was covered by elastic fibers after a short period of operation.

CLINICAL APPLICATION

1. Transplantation of dural substitute

The convexity meningioma or other dural infiltrating neoplasm can be very easily and completely removed by complete excision of the dura mater around the tumor. The dural defect is patched with dural substitute mesh much easier and quicker by surgical glue rather than by classical suturing method. Not only for this reason, but as stated in the animal experiment, suturing method causes more cortical adhesion to the dura mater. 35 cases of meningioma, 12 cases of dura-infiltrating glioma, 7 cases of metastatic tumor, 2 tuberculomas, and 5 others were operated upon with this technique, of which 2 cases had postoperative infection. One died of meningitis, but remaining case survived with intensive antibiotic therapy. Postoperative body temperature curve in these group were similar to that of other craniotomies. Four cases had recurrence of the tumors and were operated upon again. In these cases, healing and neo-membrane formation of tetoron mesh was very satisfactory with newly developed meningeal arteries over the mesh. The lining of the graft had no adhesion to the normal brain tissue.

2. Repair of broken dura mater of basal skull

Cerebro-spinal fluid leakage following the basal skull fracture can be repaired very easily with small pieces of tetoron mesh and glue. The repair could be very difficult or impossible with the sewing technique. Forceps or other surgical instruments should be coated with polyethylene material to avoid troublesome sticking.

3. Repair of broken superior sagittal sinus

Two parasagittal meningiomas were removed with a part of the wall of the venous sinus, and these were successfully repaired by this technique with satisfactory potency of the dural sinus.

4. Repair of depressed skull fracture fragmeut

The fragments was arranged with tetoron mesh and glue so that a satisfactory piece of cranioplastic bone flap could be obtained.

5. Wrapping of intracranial aneurysm to reinforce

In aneurysm which could not be clipped, tetoron mesh was applied over the aneurysm instead of coating or wrapping it with muscle.

6. Craniosynostosis

Tetoron mesh was applied over the edge of lineal craniectomy in 13 cases of craniosynostosis to prevent the adhesion between the edges of bone.

TABLE 2. Number of Cases of Clinical Application

1) Dura defect		61
a) Meningioma	35	
b) Glioma	12	
c) Metastasis	7	
d) Tuberculoma	2	
e) Head injury	5	
2) Repair of CSF leakage		5
3) Repair of dural sinus		2
4) Repair of depressed fracture		16
5) Craniosynostosis		13
6) Wrapping of intracranial aneurysm		6
	total	103

DISCUSSION

Since the first report Kirschner's application of fascia lata as a dural substitute[1], various materials have been tried for this purpose; the human amniotic membrane and fat tissue by Chao[2], fibrin film and fibrin foam by Ingraham

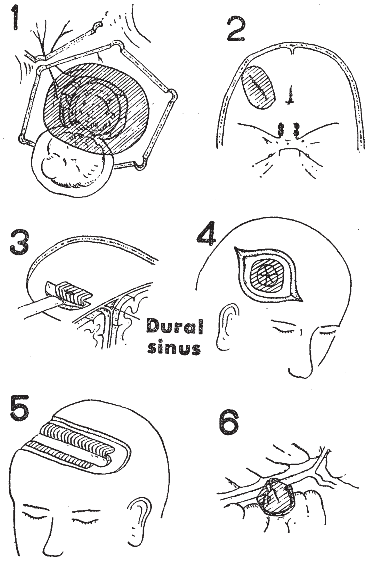

FIG. 1. Clinical application in neurosurgery
1. Complete removal of dura infiltrating brain tumor.
2. Repair of CSF leakage.
3. Repair of dural sinus.
4. Repair of depressed fracture.
5. Craniosynostosis.
6. Wrapping of intracranial aneurysm.

and Bailey[3], gelfoam film by Scheuerman, *et al.*[4], and frozen dried dura mater by Sharkey and Campbell[5][6]. In our country, Saito applied membrane of hernia sack for this purpose[7]. Beside these membrane obtained from living bodies, several metalic material such as gold foil[8], silver foil, aluminium foil, nickel foil, stainless steel plate[2] and tantalum foil[9][10][11] have been reported along this line, but in general, they have not been commonly used because of difficulity of obtaining, problems of sterilization, regional inflammatory reaction, or adhesion process of severe degree.

In the meanwhile, recent advantages of synthotic fiber made possible its uses as dural substitute by applying rubber sheet[12], polyvinyl alcohol film[13], polyethylene film[14][15], orlon[16], and vinyon "N"[17].

Kanaya[18] and Oka[19] studied on the synthetic materials as the substitute membrane with experiments on their inflammatory response or degree of adhesion process in the case of transplantation into experimental animals. They found that tetoron mesh was the best material among the available materials including vinylon, amilan, teflon, and polyethylene meshes, especially when it was coated with polyflon. They applied polyflon coated tetoron mesh for substitute of peritoneum, pleura, or diaphragm in surgery and found the least inflammatory reaction.

In this study the polyflon coated tetoron mesh was applied as the dural substitute and confirmed that this material showed the least reactive inflammation and the least adhesion onto brain surface even when there was injuried tissue around the graft and even with infection. As previously mentioned in this paper, polyflon coated tetoron mesh was covered by thin granulomatous tissue in one week and the neomembrane would be organized in one month. No adhesion over the brain surface was observed. The reactive inflammatory processes around the graft were only seen in mild degree. Furthermore, it showed practically no adhesion to neighbourhood tissues such as skull, gallea, or temporal muscle. In the animal experiments, infection of wound was seen in 3 animals. One of these infected cases showed no adhesion of membrane to underlying brain tissue even though infected wound existed epidurally. Presumably, the polyflon coated tetoron mesh has strong resistence to bacterial infection as much as the healthy dura mater does. In clinical cases, essentially the same result or even better one was observed, as far as dural graft was concerned, in the cases of re-operation for recurrent glioma. I have never applied any medication to prevent the antiinflammatory process as some authors have done such as protein anabolic hormones[20]. For dural substitute,rather tight mesh was preferable to prevent the leakage of cerebro-spinal fluid, but it should not be too fine as it could cause in the regional collection of fluid as Oka or Saito reported[19][20]. By application of surgical glue together with mesh, I experienced no cerebro-spinal fluid leakage in my series. I believe surgical adhesive method can not only protect the fluid leakage, but also accelarates the grafting maneuver. The best type of mesh for dural graft, as previously described, are that when applied prevent leakage, adhesion, and spreading of surgical glue.

The necessary conditions for artificial graft could be listed as follows,

1) No physico-chemical change by tissue fluid.
2) Chemically stable.
3) No stimmulating effect to surrounding tissue such as inflammatory reaction or foreign body reaction.
4) No carcinogenic factor.
5) No allergic or anaphylactic factor.
6) Mechanical strength for tension.
7) Economical and easily obtainable.
8) Easily sterilized[21].

The polyflon coated tetoron mesh can fulfill practically all these conditions. As for the carcinogenic factor, author is not aware of any report of synthetic fiber to be carcinogenic. For the surgical adhesive, alpha-cyanoacrylate monomer was used Dutton reported the surgical adhesive technique of methylmeta-acrylate in 1956, and later "Eastman 910" has been widely attempted for this purpose, especially for surgery of skin[22][23], intestine[24], trachea[25], blood vessels[26][72], liver[29], kidney[28], or lungs[30]. In Japan, Yoshimura *et al.*[31] and others[32][33] applied Eastman 910 or alon-alpha to the experimental organ transplantation and as an extreme example, appendectomy was performed only with adhesive technique without any stitches.

In the neurosurgical field, adhesives were used chiefly for reinforcement of intracranial aneurysm[34]. Handa *et al.* advocated EDH-Adhesive (mixture of Eastmam 910, Hycar No. 1041, and Desmodor T) for reinforcement of wall of aneurysm[35]. As described above, surgical adhesives were used only by the direct method, and the indirect method were exceptionally used in closure of skin incision. I advocated the combined application of tetoron mesh and surgical adhesives to neurosurgical technique which extended the application of adhesive technique much broaderly in clinical application.

As mentioned before, alpha-cyanoacrylate has sufficient promptness and intensity in adhesive mechanism for neurosurgical use. It has sterilizing power[36] and it could be broken to HCN gas only under high temperature above 250°C, but never be broken under usual circumstances[37]. Ota states alpha-cyanoacrylate has less tissue reaction to compare with Eastman 910 or cyanobond[38]. Ota observed absorption of glue in the tissue in several months without evidence of degeneration or necrosis of surrounding tissue[39]. He states the tendency of absorption of adhesive in tissue correlates with number of its side chains of ($CnH2n+1$) alcohol value in chemical structure. In the present experiment, adhesive material in the connective tissue or over the dura mater is observed its emigration from originally transplanted region in one month and, in most cases, it disappears after 3 months with trace of phagocytosed material around the transplanted tetoron mesh. Six months later, it disappears completely. These experimental observations were recomfirmed in clinical cases of re-opening of craniotomy for recurrence of brain tumor. Although, it is impossible to make neurosurgical operative field completely dry because of natural necessity of moisture of brain tissue, polymerization of alpha-cyanoacrylate from monomer type to polymer type does not need perfect dryness. Dura mater or other structure in neurosurgical operation holds no tension and when they are closed the situation differs from surgery of the intestine or the vascular system.

More than one hundred clinical cases of neurosurgcal operation were studied in the present experiment. Among them, 61 dural graft were made, this is most useful application in this technique and can be used routinely since it accelarates the time of dural patch as well as it prevents the cerebro-spinal fluid leakage. In 13 cases of craniosynostosis, the tetoron mesh fixed with surgical glue was applied along the edge of lineal craniectomy. In 16 cases of depressed skull fracture, the fragments were patched with tetoron mesh lining by adhesive. This technique can save the extra work to make tantalum plate or other artificial bone graft such as acrylate resin plate. In 6 cases, It was tried to reinforce the wall of intracranial aneurysms by covering them with tetoron mesh glued by alpha-noacrylate monomer. This prevent the extra adhesion of coating glue to surrounding tissue. Tetoron mesh adhesive technique is most useful when it is applied to patch the base of skull of cerebro-spinal fluid leakage as hitherto used patch technique was hard to close the narrow base of skull. Broken dural venous sinus can be readily repaired with this technique for the complete removal of parasagittal meningioma or other operative procedure along superior sagittal sinus necessitate the repair of this important vein.

A project to produce the artificial dural sinus, which will enable graft with surgical adhesive, has been progressed in our laboratory.

For operative procedure with cyanoacrylate adhesive, polyethylene sheet or polyethylene coated surgical instruments would be desired to prevent the additional adhesion.

SUMMARY

In this paper, I described the basic study with histological follow up in animal experiment and clinical application of cyanoacrylate adhesive-polyflon coated tetoron mesh technique.

In the study of experimental basis, adult dogs were used for experimental animal, transplanted tetoron mesh dura substitute intracranially with various conditions and tried to repair and patch the artificially broken dural venous sinuses. Operations were made according to the clinical neurosurgical technique with good care to avoid the infection, but 3 of them were made intentional post-operative infection to see how those materials work with infection under the antibiotic therapy. No contraindicated condition was noted with application of this technique. Animals were sacrificed in 10 to 180 days after the experimental surgery for histological observation.

As to adhesion between mesh and cortical surface of brain, it was seen more markedly in the group of dural graft with sewing technique rather than in the group of surgical adhesives. Adhesion around the sewed area was seen 7 instances among 16 dogs. These cortical adhesion were seen more among the cases of cortical injury. Tetoron mesh is covered by thin granulomatous membrane within 10 days and round cell infiltration is obsreved in moderate degree. One month later, cellular infiltration reduces its degree and the membrane would be organized. After one month the reduction and emigration of the adhesive material is already noted and, in most cases, it disappears after 3 months. Six months later, no glue was found in histological investigation and newly developed granulation takes the place to it. As for surgical adhesive technique, it was experimenced no cerebro-spinal fluid leakage in the series.

Broken dural venous sinus can be readily repaired with this technique, and no occlusion of the vascular canal was observed.

I have the experience of 103 cases of neurosurgical operations, and I advocate the extensive usage of this tetoron mesh adhesive technique which gives superior result in clinical application, and it is most useful when it is applied to patch the base of skull for cerebro-spinal fluid leakage and broken dural sinus as hitherto sewing technique was very difficult or impossible.

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EXPLANATION OF FIGURES

PHOTO. 1. Case F.E. 39 yrs, female (Photo 1. a. b. c. d.) Diag: Spongioblastoma of right occipital lobe. This patient started to have convulsive attackes 4 months prior to her admission. Headache with nausea and vomiting started 3 months prior to admission.

Craniotomy on the March, 12, 1966 revealed fairly demarkated tumor over the right occipital lobe and there was tight attachment of tumor into inner surface of dura mater. Tumor was totally removed with attached dura mater (Photo. 1. a. b.).

Photo. (1. c.) shows the cavity where the tumor was removed and dural deficit because a part of dura mater was excized with tumor in order to prevent recurrence from the tumor attachment.

Photo. (1. d.) shows the dura substitute graft with adhesive technique. This patient had uneventful postoperative recovery and fully active 22 months postoperatively.

PHOTO. 2. Shows the dural graft over the deficit of orbital roof by head injury. This patient was involved in an auto-accident and had fracture of the basis of anterior cranial fossa which caused exophthalmos of this side. Fragments were removed and dural plastic operation was made to prevent the cerebrospinal fluid leakage.

PHOTO. 3. Application of tetoron mesh adhesive technique on the craniectomy for craniosynostosis. Note the paths along the craniectomies and this can save time and risk of bleeding, comparing with regular procedure with sewing method of polyethylene membrane.

PHOTO. 4. Application of this technique for fixation of bone flap. This patient had a fairly large parieto-occipital parasagittal meningioma and the repair of superior sagittal sinus was also made after complete removal.

PHOTO. 5. Shows the follow-up study of the mesh after $1\frac{1}{2}$ years. Lining of mesh with the thin layer of fibrous tissue reveals no adhesion onto the cerebral cortex.

PHOTO. 6. Shows the edge of transplanted tetoron mesh. Note the fibers of mesh with thin layer of fibrous tissue as the dural lining. The upper portion shows the used alpha cyanoacrylate monomer and as one can notice, surgical adhesives emigrate out of the mesh and eventually phagocytosed and absorbed away.

PHOTO. 7. This is the transplanted mesh after $1\frac{1}{2}$ years. In this cases. re-operation for recurrent glioma was made and the transplanted mesh showed no adhesion onto the cerebral cortex.

PHOTO. 8. Shows the histological finding of transplanted mesh after almost 2 years. A 38 year-old male had recurrent glioma in left fronto-parietal lobes and this sample was made at the second craniotomy. Note that the transplanted mesh protect the tumor to be infiltrating out through the mesh.

PHOTO. 9. Shows the histological study of animal experiment of A-type, and on the 10th day adhesives can be noticed remaining in the transplanted area, but no adhesion of pacth onto the cerebral cortex is seen.

PHOTO. 10. Experiment of type A (20th day). Adhesion of mesh onto the cerebral cortex is minimum.

PHOTO. 11. In animal experiment, the applied surgical adhesives eventually is phagocytosed and emigrated away. This sample was taken on the 20th day after transplantation. Experiment of A-type.

PHOTO. 12. Animal experiment of type A (20th day). Note the relation ship of grafted mesh, developed fibrous tissue as the lining, and cerebral cortex. This histological section shows the cortical adhesion to some degrees which is exceptional as described in my article.

PHOTO. 13. Follow up study of mesh and surgical adhesives after 30 days. As noted, cellular infiltration around the graft is minimum. Experiment of type A.

PHOTO. 14. Animal experiment of type A (60th day). Note the broken mesh of dural substitute. Lining of the mesh become dence and no adhesion is seen over the cerebral cortex.

PHOTO. 15. Animal experiment of type A (90th day). This shows almost completely broken tetoron mesh but well organized neo-membrane. Note the cerebral cortex is free from adhesion.

PHOTO. 16. Animal experiment of type C (sewing method) on 20th day. If sewing procedure was made without injury of underlying cerebral cortex, there is no adhesion noted between tetoron mesh and brain surface, but as fig. 17 shows, sewing technique in animal experiments easily caused cortical injury with resulting adhesion.

PHOTO. 17. Experiment of type C on the 30th day. In this experiment, cellular infiltration is noted to severe degree with cortical adhesion. and this is probably due to cortical injury by sewing procedure. By sewing procedure, especially in animal experiment, the cortical injury is hard to avoid by maneuver where as experiment of type A reveals no risk of injury of brain surface which eventually results in adhesion.

PHOTO. 18. Animal experiment of type D (intentional cortical injury at the time of dural graft) on the 20th day. As Photo. 18 shows, severe adhesion between dural substitute and injuried brain surface is noted.

PHOTO. 1. a

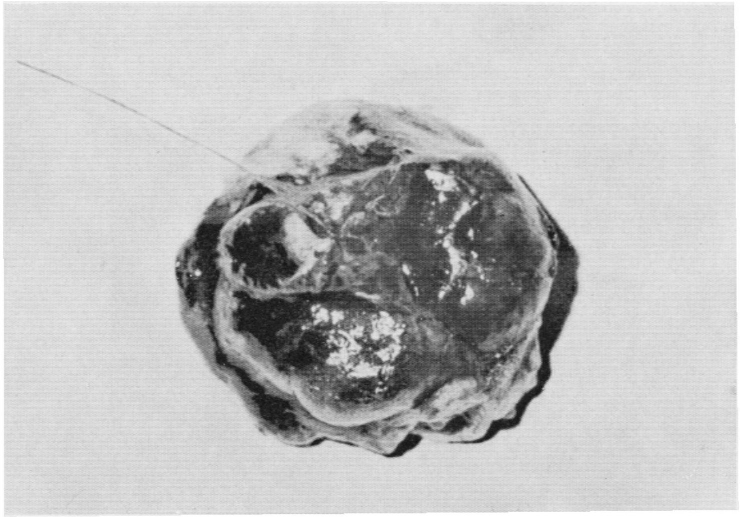


PHOTO. 1. b

PHOTO. 1. c

PHOTO. 1. d

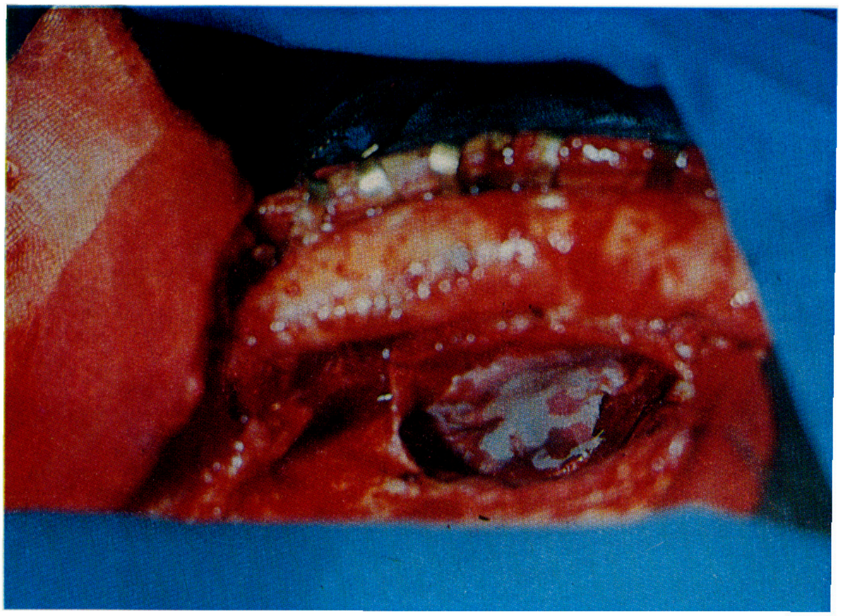


Photo. 2

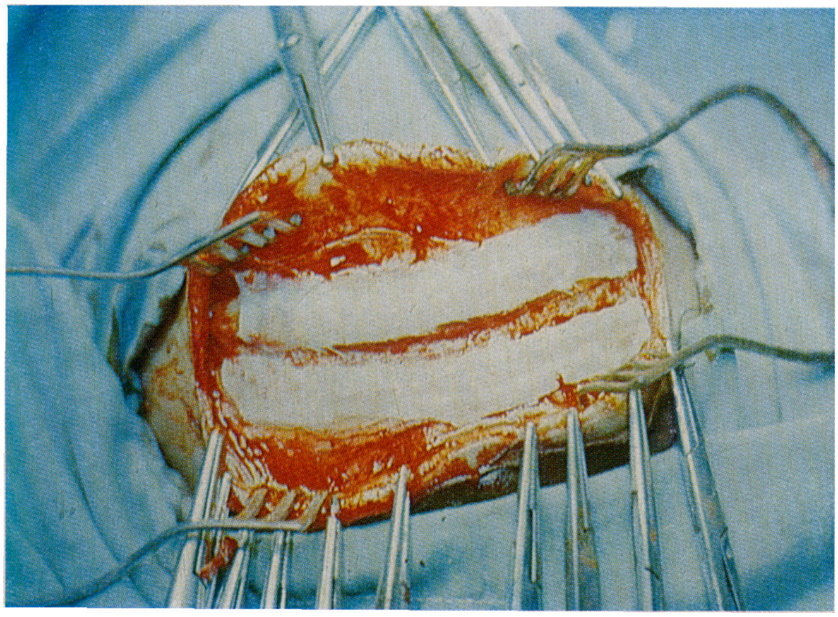
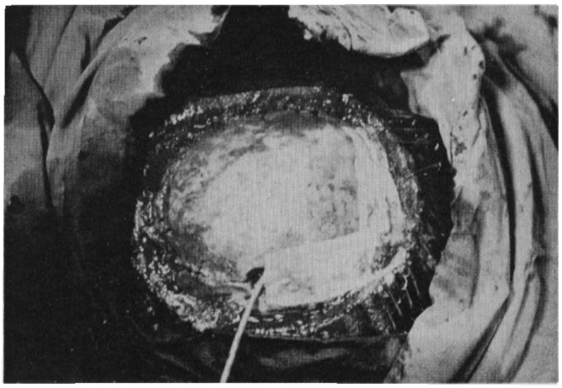


Photo. 3



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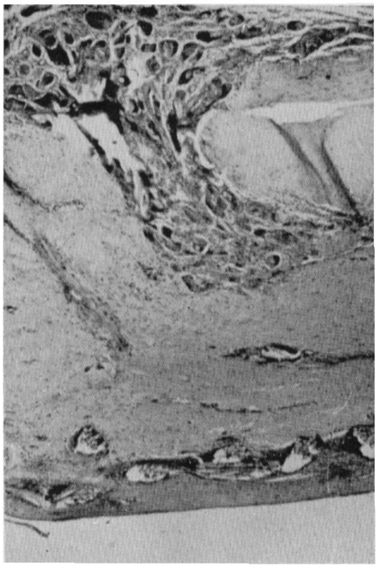

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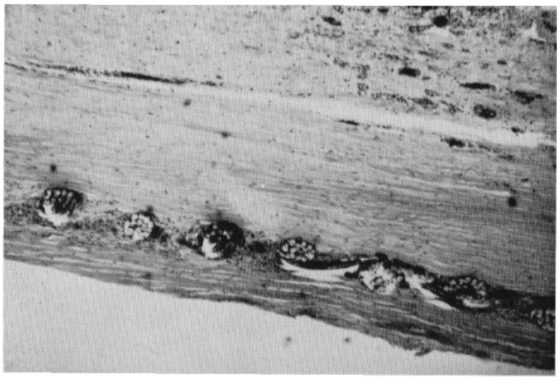

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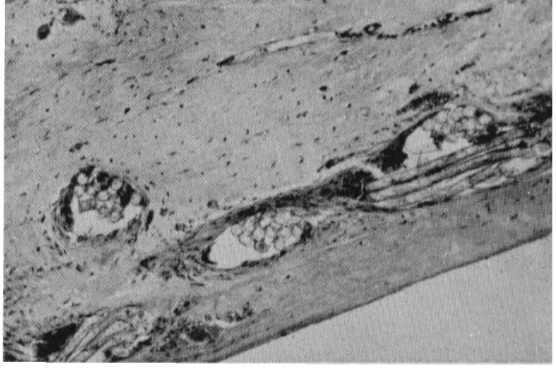


PHOTO. 7

PHOTO. 8

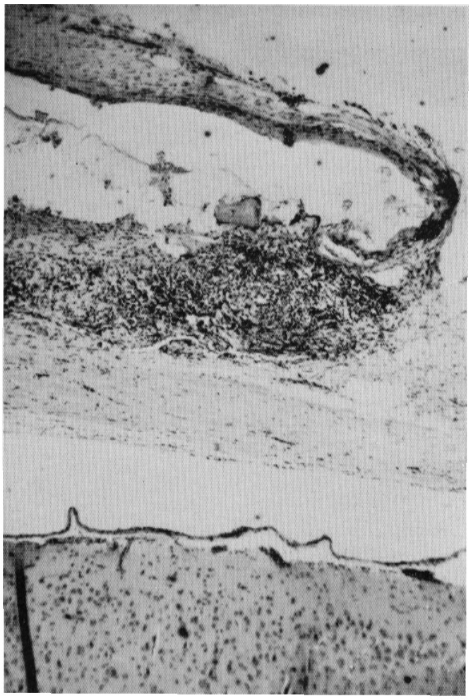


PHOTO. 9

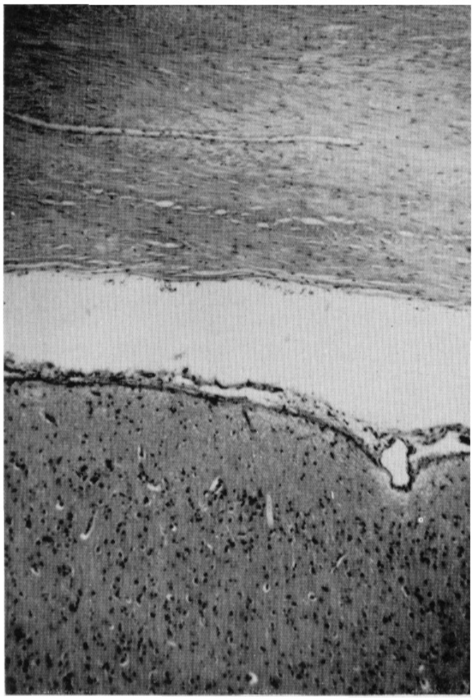
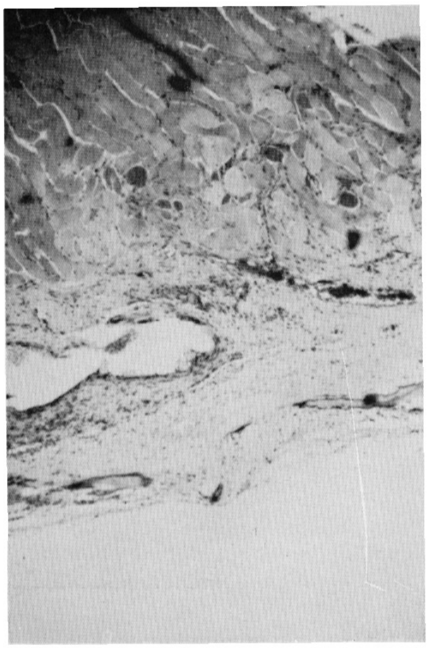


PHOTO. 10



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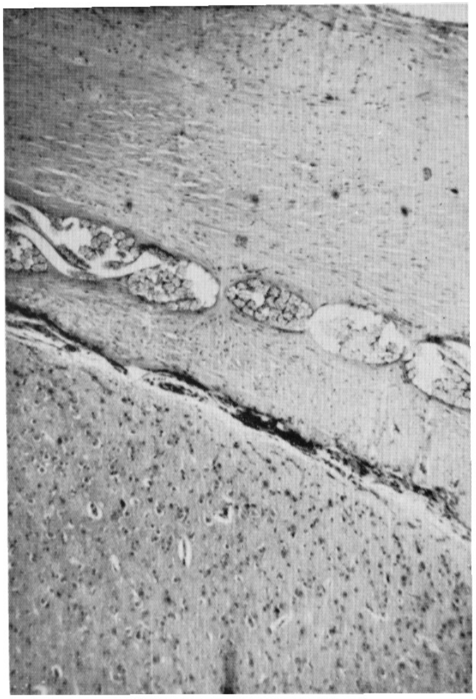

PHOTO. 12

PHOTO. 13

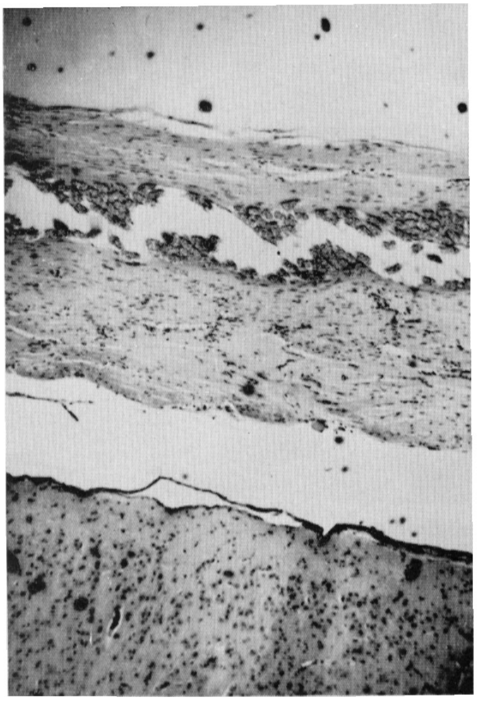

PHOTO. 14

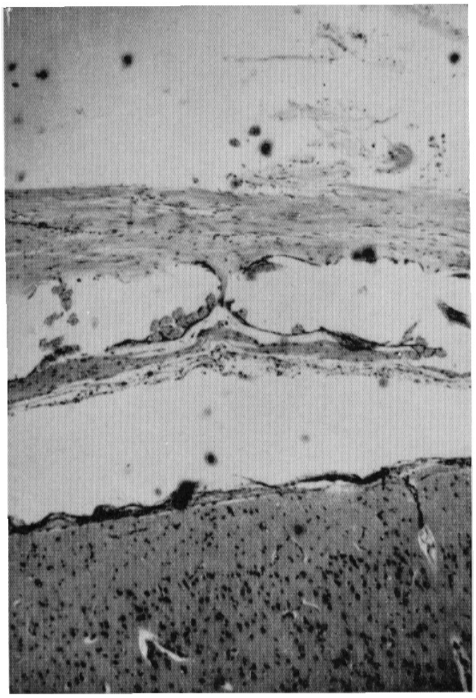

PHOTO. 15

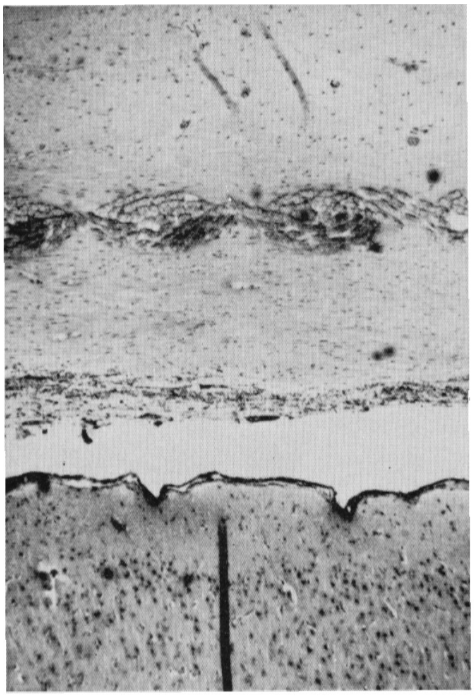

PHOTO. 16

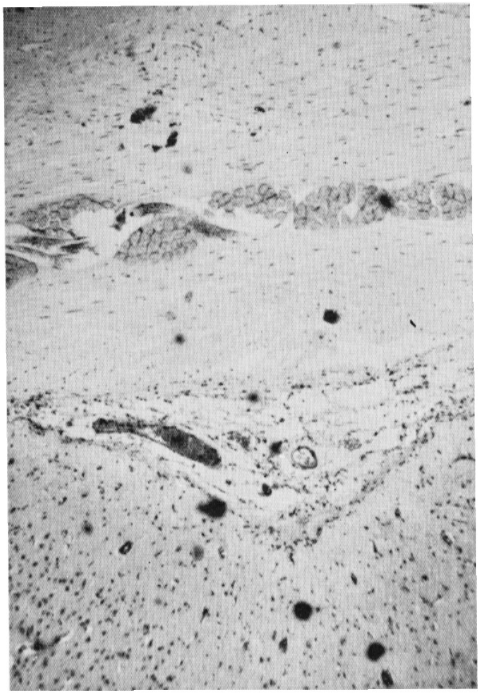

PHOTO. 18

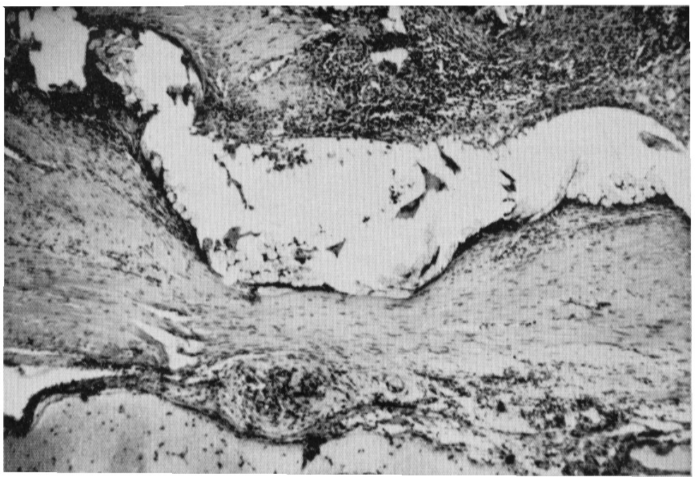

PHOTO. 17