The use of Teflon as a dural substitute and its other neurosurgical applications

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During the last seven decades many materials have been experimentally tried as dural substitutes, and many have been discarded after being clinically introduced. In recent years, satisfactory results from Orlan (Huertas, 1955), Vinyon 'N' (Teng and Feigin, 1955; Teng, 1961), and homologous dura mater (Crawford, 1957; Campbell, Bassett, and Robertson, 1958) as dural substitutes have been reported. Vinyon 'N' has been out of production because it is of no commercial value. It is replaced commercially by Teflon. The present communication concerns the introduction of Teflon cloth as a dural substitute and its other neurosurgical applications. It has been clinically tried during the last two and a half years at the Kaiser Foundation Hospitals of Southern California.

THE TEFLON

The Teflon cloth¹ is woven in the form of China silk. It is soft, flexible, and dark brown in colour (unbleached). It has a smooth, waxy, and non-adherent surface. In sterilization for medical use, it withstands heat, wet or dry, 350° to 400° F., undamaged. It has been repeatedly autoclaved at 270° F. under 30 lb. for five to 10 minutes without any noticeable alteration of its properties. It is well known in the field of cardiovascular surgery, in which braided Teflon tubes are extensively used as aortic and arterial replacements. In this respect, the fine pores of the Teflon do not hinder its use as dural substitute when waterproofing is desirable.

Possible industrial hazards caused by Teflon have been discussed by Tepper (1962). When Teflon burns it generates poisonous fumes. However, this is unlikely to happen in an operating room where open flame is not allowed. Teflon is not inflammable and it has a high melting point. The use of an electrical cautery in the neurosurgical wound would not kindle it.

¹Teflon cloth bought from Stern and Stern Textile Co., New York, New York.

CLINICAL OBSERVATIONS

From November 1959 to August 1962 Teflon cloth was used in 36 neurosurgical cases. In 31 patients it was used as dural substitute (for cerebral dural defect in 25, cerebellar dural defect in three, and spinal dural defect in three). In four infants Teflon was utilized as bone lining in craniectomy for craniostenosis. In one patient after neurolysis of the left common peroneal nerve in severe cicatrization it was used as a nerve wrap. The time of observation in these 36 cases varied from two to 33 months (Table I).

AS CEREBRAL DURAL SUBSTITUTE Teflon cloth was used to cover cerebral dural defects in 25 cases (including three metastatic carcinomas, one metastatic melanoma, two cerebral lacerations), and in four after clipping an aneurysm of the anterior communicating or internal carotid artery. In these four cases the frontal dural flap was not closed at the end of the operation but loosely replaced over a strip of Teflon cloth, which was used to bridge the gap. In five cases of meningioma, one epidermoid, and nine gliomas, the dural flap was discarded and replaced by Teflon cloth. In each instance, the Teflon cloth was tucked under the edge of the dura in order to prevent meningo-cerebral adhesions often noted through the suture line in edge-to-edge anastomosis. No ill-effect has been observed in this group. The longest period of observation was 33 months.

In five cases the Teflon cloth was recovered 123, 140, 152, 223, and 251 days respectively after being placed in position. The first specimen was lost and four were examined microscopically. At necropsy, dense fibrous tissues were noted on the outer surface of the Teflon cloth. The edge of the incised dura was buried in the scar and firmly adherent to the outer surface of the Teflon. The under surface of the Teflon cloth was free of adhesions. It was easily lifted off the cerebral cortex, including the area of biopsy or the area of the transcortical incision

TABLE I
TEFLON CLOTH RESIDENT IN TISSUE

Case No.	Manner of Utilization	Diagnosis and Site of Teflon Used	Date of Operation	Size of Teflon (in.)	Remarks
1	Substitute for cerebral dura	Cerebral laceration, R. temporal	1/6/60	2 × 2	Living, no convulsion
2		Cerebral laceration, L. frontal	1/6/60	2 × 2	Living; wound infected, removed 3 mth. later; pus and granulations outside cloth; convulsions appeared 2 wk. after removal of Teflon
3	Substitute for cerebral dura	Metastatic carcinoma, R. parietal	11/25/59	2 × 3	Died, 2/6/60, no necropsy
4		Metastatic carcinoma, R. temporal	3/24/60	3 × 3	Died, 8/11/60. Teflon recovered
5		Meningioma, L. pterion	9/28/60	3 × 3	Living and well
6		Malignant meningioma, R. fronto-parasagittal	5/24/60	3 × 3	Died, 9/25/60. Teflon recovered
7		Metastatic carcinoma, R. temporal	7/11/62	3 × 3	Living
8		Metastatic melanoma, L. temporo-parietal	7/16/62	3 × 3	Living
9		Meningioma, L. pterion	1/10/61	3 × 3	Living
10		Meningioma, R. frontal parasagittal	2/2/61	3 × 3	Living
11		Meningioma, L. posterior frontal parasagittal	5/25/61	3 × 3	Living
12		Epidermoid, dura involved L. frontal	5/29/62	1 × 2	Living
13		Glioblastoma multiforme, R. posterior frontal	1/30/61	3 × 3	Died, 2/17/61, no necropsy
14		Glioblastoma multiforme, L. parietal	5/4/61	3 × 3	Living
15		Glioblastoma multiforme, L. temporal	8/31/61	3 × 3	Died, 4/10/62, Teflon recovered
16		Astrocytoma, L. fronto-temporal	9/14/61	3 × 3	Living
17	Substitute for cerebellar dura	Glioblastoma multiforme, temporal	10/12/61	3 × 3	Died, 6/20/62, Teflon recovered
18		Glioblastoma multiforme, L. temporal	12/13/61	3 × 3	Died, 3/10/62, no necropsy
19		Glioblastoma multiforme, L. parietal	1/8/62	3 × 3	Living
20		Glioblastoma multiforme, L. temporal	3/15/62	3 × 3	Died, 8/1/62, Teflon recovered
21		Glioblastoma multiforme, L. temporo-parietal	6/11/62	3 × 3	Living
22		Aneurysm, anterior communication artery, bifrontal bone flap; clipping of aneurysm	10/7/59	3 × 3	Living
23		Aneurysm, anterior cerebral artery, clipping, R. frontal flap	1/12/61	each side 3 × 2	Living
24		Aneurysm, anterior communicating artery, clipping, R. frontal flap	2/8/62	3 × 2	Living
25		Aneurysm, internal carotid artery, clipping, R. frontal flap	6/28/62	3 × 2	Living
26		Arnold-Chiari anomaly, posterior fossa-spinal decompression	6/11/60	3 × 4	Living
27	Substitute for cerebellar dura	Pearly tumour, R. petrous	6/12/62	3 × 3	Living
28		Meningioma, R. posterior fossa	8/8/62	4 × 3	Living
29		Glioma, intramedullary, C2-C6	2/1/62	2 × 4	Living
30	Substitute for spinal dura	Meningioma, D8-D9	2/2/62	1 × 1	Living
31		Vascular anomaly, D3-D9	6/28/62	2 × 8	Living
32		Synostosis, sagittal suture, R. parasagittal craniectomy	3/23/60	1½ × 7	Living
33	Bone lining in craniostenosis	Synostosis, sagittal suture, R. parasagittal craniectomy	3/23/60	1½ × 7	Living
34		Synostosis, sagittal suture, R. parasagittal craniectomy	5/12/60	1½ × 7	Living
35		Synostosis, sagittal suture, R. parasagittal craniectomy	10/20/60	1½ × 7	Living
36	Peripheral nerve wrap	L. common peroneal nerve, cicatrization; neurolysis	4/13/62	2 × 8	Living

through which the tumour had been partially removed. Gliosis at the operative site was obvious but there was no adhesion to the under surface of the Teflon in all five cases. The cortical vessels appeared normal. They too did not adhere to the cloth. The pia throughout the area covered by the cloth was neither thickened nor changed in colour in comparison with the same region of the opposite hemisphere not clothed with Teflon. Microscopic examination found occasional lymphocytes lodged between the meshes of the Teflon fibres, but there was no foreign body giant cell. The underlying cortex displayed no noticeable change. Figures 1, 2, and 3

are specimens removed from one patient 251 days after the Teflon cloth was placed over the fronto-temporo-parietal region of the left hemisphere. The lack of both gross and microscopic reaction is obvious.

AS CEREBELLAR DURAL SUBSTITUTE In three cases Teflon cloth was used to cover the dural defect created by a posterior fossa craniectomy. In all three cases the dura was left open. One operation was for the removal of a right posterior fossa meningioma and one for a partial removal of a petrous epidermoid tumour. The third case was for

FIG. 1. Case 17. Teflon cloth (black patch), intracranial, resident 251 days as dural substitute.

A Natural dura mater

B Reflected dural substitute, Teflon cloth

C Black silk outlines area covered by Teflon.

Arrow indicates area of gliosis following biopsy.

Note that the leptomeninges are thin and transparent. Normal configuration of cortical vessels and absence of adhesion including area of gliosis.

decompression of an Arnold-Chiari anomaly with obstruction at the craniospinal junction. The third patient, who was operated upon 27 months ago, is illustrated in the following:

This 36-year-old housewife was operated upon on 11 June 1960. An Arnold-Chiari anomaly was exposed through a posterior fossa craniectomy and C1-3 laminectomy. The cerebellar tonsils extended to C2 and the medulla was 'hunchback' in appearance. The cerebello-spinal dura was left open. The gap was tented with a piece of Teflon

FIG. 3. Specimen from the same case. Magnification of A_1 of Fig. 2 $\times 250$. Cross-section of Teflon cloth fibres. Note the absence of cellular reaction.

cloth. Up to date, 27 months after surgery, the patient has been asymptomatic and leading a normal life. The Teflon cloth has not produced any untoward effect.

AS SPINAL DURAL SUBSTITUTE The Teflon cloth was used to cover spinal dural defects in three cases, one to cover an extensive vascular anomaly of the dorsal spinal cord and one after the removal of a meningioma from D8, two to seven months ago,

FIG. 2. Same case. $\times 100$.

A Teflon cloth fibres

B Pia mater

C Cortex of left temporal lobe.

Note the lack of tissue reactions and normal appearance of the pia mater and cerebral cortex.

respectively. In the former case, the large coils of abnormal vessels herniated through the incised dura, which was left open with its gap covered by Teflon. In the third case, an intramedullary glioma involving the cord from C2 to C7 was biopsied and decompressed by leaving the dura open and covering with Teflon. Up to the time of preparation of this article, eight months have elapsed since surgery, and the patient is still able to work as a clerk at a store for electrical supplies. He walks without a cane but his left hand is weak in skilful manoeuvres. No untoward effect appears to have been caused by Teflon in these three cases.

AS BONE LINING IN CRANIOSTENOSIS AFTER CRANIECTOMY In four infants with premature closure of the sagittal suture, Teflon cloth was used as bone lining after craniectomy to prevent reunion of the bone edges. These cases were followed 23 to 30 months. No ill effect has been caused by Teflon.

AS NERVE WRAP IN CICATRIZATION. In one case, the left common peroneal nerve was involved in severe cicatrization following chronic osteomyelitis for three years as a result of a compound fracture. For the relief of pain, the nerve was dissected free from the surrounding dense scar tissue and wrapped with Teflon cloth. Since the operation five months ago the patient has been free of pain. During the previous two years, three operations for neurolysis were performed, and invariably pain recurred three to five weeks after each attempt.

DISCUSSION

It is generally believed that the meningo-cerebral adhesions that follow injury or surgery are responsible for the post-traumatic or post-operative convulsive disorders. The purpose of using a dural substitute is to prevent adhesions and cross-circulations between the exposed brain and the overlying soft tissues rather than to fill the defect in the severed dura mater.

A dural substitute must possess specific qualities: it must not be toxic, it must be inert in tissues, not absorbent, resistant to disintegration, of a favourable tensile strength, of a soft consistency, easy to manipulate for wrapping over the surface of the brain, of adequate supply, and easy to sterilize.

The present study indicates that Teflon cloth is chemically inert and not irritating. It has produced

no untoward effect in the clinical test. It has remained in tissues for periods of from two to 33 months in 36 patients. A comparative study of the properties, resources, and method of sterilization of Orlan, homologous dura mater, and Teflon is presented in Table II.

Albin, D'Agostino, White, and Grindlay (1962) reported their observation on bleached Teflon coated with methyl 2-cyanoacrylate. They found in their experimental animals that a fibrous membrane had formed on both surfaces of the coated Teflon cloth used as dural substitute. This has not been observed in our cases, in which the unbleached and uncoated Teflon was used.

Its use in craniostenosis, for the prevention of bone reunion after craniectomy, has also shown satisfactory results. It is soft and easy to use for lining the bone incision.

One of the aims of neurolysis is to prevent recurrence of compression by regrowth of scar tissue along the course of the dissected nerve, and it has often been a problem to find a healthy soft tissue bed for transplantation of the nerve after neurolysis in cases of severe and extensive cicatrization. In such instances, Teflon cloth provides a satisfactory wrap to protect the nerve from the constricting scars.

SUMMARY

Teflon cloth, a synthetic fabric, has been used as a satisfactory dural substitute, nerve wrap, and bone lining in craniostenosis after craniectomy in 36 cases. The periods of observation ranged from two to 33 months.

Teflon cloth is chemically inert, heat resistant, and is not toxic. It is not absorbed and has a tensile

TABLE II

A COMPARISON OF VARIOUS DURAL SUBSTITUTES RECENTLY USED OR TESTED

	Source	Structure	Durability	Flexibility	Tissue Reaction	Method of Sterilization
Polyethelene (Ingraham <i>et al.</i> , 1947)	Synthetic product	Non-porous sheet	Non-absorbable	Flexible	Thin fibrous capsule formation; minimal cellular reaction	Soaking in Zephiran 1:1,000 solution
Orlon	Synthetic product	Cloth	Non-absorbable	Silk-like	No capsule formation; minimal cellular reaction; no foreign body giant cells	Autoclave
Vinyon 'N' (out of production)	Synthetic product	Cloth	Non-absorbable	Silk-like	No capsule formation; cellular reaction including few foreign body giant cells	Boiling in water
Homologous dura mater	Human body	Dehydrated dura	Partially absorbed, replaced by fibrous tissues	Less flexible	Minimal cellular reaction; no foreign body giant cell; replaced by fibrous tissues	Ethylene oxide immersion; freeze-drying
Teflon	Synthetic product	Cloth	Non-absorbable	Silk-like	No capsule formation; minimal cellular reaction; no foreign body giant cell	Autoclave

strength as silk. It can be sterilized by autoclave and it is in abundant supply. It causes negligible tissue reactions.

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