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Review Article:
Facial Paralysis: Reconstructive Surgery: State of Art

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INTRODUCTION

Facial paralysis is know as moebius syndrome. It is classically defined as combined congenital bilateral facial and abducens nerve palsies, although it can be associated with amyriad of other craniofacial, Musculoskel et al., cardiothoracic and developmental disorders. It is a neurdogical condition which results from a lesion of the 7th cranial nerve resulting to an acute onset of weakness or total paralysis on the ipsilateral side of the face. It is characterized by total loss of voluntary muscle movement of one side of the face and an individual who is incapable of expressing their emotions or any kind of reaction through their face. Facial paralysis is common condition happens following injury to nerve either intracranial or extracranially. The intracranial injury is either due to trauma, tumors and surgical procedure in brain stem area. Human face is a significant part of our identity, the face is our calling card to the world. Expression represent a complex language reflecting internal feelings. A warm smile extends an invitation for social interaction and friendship. A facial deformity disease or trauma, can case various problems. Fortunately innovative surgical techniques are now available to restore the paralyzed face. Several options are available to treat patients with facial paralysis. A thorough examination and determination of severity can be performed. Plastic and reconstructive surgeon's can restore a patients appearance through wide range of reconstructive surgery. Due to difficult approach to these areas, the direct repair of nerve is normally not possible and other procedures are adopted.

In extracranial paralysis is injury to nerve after it comes out through from the temporal bone under the mastoid process and pass through parotid gland. Facial paralysis is more common due to involvement of this area of facial paralysis. The common reasons are:

- *Bell's palsy*: This is viral infection of nerve leading to oedema in close tunnel in temporal region resulting into temporary or permanent loss of nerve fibers.
- *Parotid tumors:* Most of benign tumour does not involve facial nerve, however in malignant tumors facial nerve is commonly involve leading to paralysis.
- *Trauma:* Direct trauma to mastoid region can result into facial paralysis.
- *Surgical trauma:* Though uncommon, mainly involves branches of facial nerve than whole nerve.
- *Congenital:* Some of lesion like hemifacial microsomia may has associated involvement of nerve leading to paralysis.

Classification:

The facial paralysis are divided into two types, supranuclear and infranuclear system.

- *In Supranuclear palsy:* It is involvement of central nervous system when the fiber of facial nerve proximal to facial nucleus in pons are involved. In this type, the palsy is on the opposite side of the injuries in brain. The facial nerve supplying frontalis muscles are spared due to crossing of fibers from the opposite side. The main causes are like cerebrovascular stroke, haemorrage or tumour in this region.
- *Infranuclear palsy:* It is involvement of pheripheral nervous system, when the facial nerve is affected after its nucleus in pons. Any involvement of infranuclear facial palsy will result into totally paralysis of ipsilateral facial muscles involving complete half of the face. This type of palsy commonly seen in Bell's palsy and parotid tumors.

Goals of reconstruction of facial paralysis:

- Facial symmetry at rest.
- Reestablishment of facial symmetry in repose and aspontaneous (natural looking) smile.
- Voluntary, coordinated, spontaneous facial movements.
- Oral competence and eyelid closure with corneal protection.
- Absence or limitiation of synkinesis and mass movement.
- Normalize muscular ton.
- To relief pain.
- To prevent complications.

Function and anatomy of facial nerve: Facial nerve paralysis is the unfortunate end product of a large series of complex disorders. Inciting events include tumors, trauma viral infections (belly palsy), strokes and congenital difference such as moebius syndrome, craniofacial microsomia and C.H.A.R.G.E syndrome. The facial nerve controls the muscles of facial expression, tearing and the eye and taste. It does not control the muscles of mastication or chewing. It is very essential to study the anatomical course of facial nerve for treatment. Because it is the most visible paralysis of the body, and most important due to involvement of facial muscle, anatomy of facial nerve is studied in great details with availability of extensive literature. There are two important area of extracranial path of facial nerve.

- *Intratemportal facial nerve:* As soon as it comes out from pontine angle it crosses the internal meatus and enters the facial nerve canal passing through middle ear. During this course it gives rise to three branches:
  - Greater superficial petrosal nerve: Secretomotor fibers to lacrimal gland.
  - Nerve to stapedius muscle.
  - Chorda Tymapni: Secertomotor fibers to submandibular and lingual gland and taster fibers to anterior 2/3 of tongue.
- *Extratemporal facial nerve:* This is the most important course which needs to be understood for the surgical treatment. Facial nerve after emerging from stylomastoid foramen travels for 1 to 1.5cm, corsses posterior belly of digastrics muscle medially and passes later to styloid process, before it enters parotid gland (Fig. 1). During this course, it lies medial to external carotid artery and posterior facial vein.

After it enters the parotid gland it divides into two branches:

- Temporofacial.
- Cervicofacial.

The temporofacial gives rise to temporal, zygomatic, buccal braches, while cervicofacial gives rise to mandibular and cervical branches. These terminal branches have many variable and complex connections and crisscrossing of branches and nerve fibers. As the main trunk runs anteriorly, it becomes more superficial and comes out at the anterior border of the gland. At the anterior border of parotid gland, the branches are very superficial and without protection of the gland and more likely to get injured during surgical procedure.

- *Temporofacial division:* It gives rise 5 to 7 branches, with multiple criss-crossing of smaller branches. The braches are usally one frontal brach to frontalis muscle, two orbital branches to orbitalis oculi, three zygomatic branches to orbicularis oris and elevator of upper lip, angle and nose. The frontal branch has very few interconnection while zygomatic branch has many interconnections. These branches lies on external surface of buccal pad of fat and under the masseteric fascia. Any dissection deep to SMAS in region anterior to the border of master is likely to injure the facial nerve (Fig. 2).
- *Cervicofacial division:* The smaller of two division supplies lower face and neck. It divides into 3 to 5 branches. One buccal branches for buccinators, one mandibular branch for depressor of lower lip and cervical branch for platysma. The mandibular branch also known as rima mandibularis, is the most commonly injured branch during surgical procedures. This branch also has very few connection with other facial branches. Rima mandibularis posterior to facial aretery runs above the inferior border of mandible in 80% of time, and remaining time it may be passes lower to inferior borer almost about 1cm below. Anterior to facial artery, this branch almost always runs above the inferior border of mandible **[1]**. In some of older individual with atrophic and lax tissue, these branches can run as low as 3-4 cm below mandible border **[2]**.

All the nerve branches, most of the time enters the muscles from the deeper aspect and therefore protected in most distal part. Extratemporally, the blood supply for nerve is coming from a branch from stylomastoid artery. Venous drainage of nerve drains into parotid venous plexus.

Facial muscle anatomy:

It is very essential to have some outline of facial muscles while studying the facial palsy. There are 27 pairs of facial muscles which are supplied by facial nerve. Most of the facial muscles are closely connected to the overlying skin which activates the facial expression.

- *Upper face muscles:* The upper face has frontalis muscles, corrugators, procerus and oribitualris oculi. All these muscles at junction interdigitate with each other to provice smooth facial expression. The orbitalis oculi is divided into orbital, preseptal and pretarsal components.
- *Mid face muscles*: These are muscles of zygomatic, nasal, cheek and oral commissure. Nasal muscles are levator alaque nasi and nasalis.
- *Lower face muscles:* Depressor of lower lip, Quadratus Labii inferiorus, depressor anguli oris, platysma, posterior belly of diagastric. The deviation and deformities are on normal side (Fig. 3).

Causes of facial nerve paralysis:

- *Bell's Palsy:* This is one of the commonest reason for facial nerve paralysis. It is caused by viral infection of mastoid air sinuses, leading to inflammation and oedema of facial nerve in tight bony canal. The paralysis is sudden and observed usually overnight. The paralysis is reversible as the edema reduces. In >70% of patients, the facial paralysis recovers and achieve full function of facial muscles. However in remaining 30% of cases some weakness persist and 10% have permanent paralysis.
- *Cerebrovascular stroke:* Another common cause for facial paralysis, which is usually due to ischemia and infarction of brain, specially of the nuclei. In these cases, the paralysis is suramuclear type and forehead muscles would have been spared.
- *Parotid tumours:* This is commonly associated with malignant tumours of parotid and often need excision of part of facial nerve.
- *Surgical trauma:* Any surgical procedure like parotidectomy to face lift can damage the facial nerve in extratemporal course. Intratemporal course, it is middle ear surgery or mastoid surgery where facial nerve is prone for the injury. Intracranially, any brain stem tumour surgery can damage either the nuclei or nerve course leading to facial paralysis.
- *Trauma:* Any direct or indirect facial trauma can lead to facial nerve injury and paralysis.

Investigation and evaluation:

Electrodiagnostic testing is usually done following nerve injuries. However, if clinically diagnosis is clear then, these tests become academic exercise. However, in case of doubt regarding the site of injury, the electrodiagnostic tests help to localize the lesion. The serial testing done at the interval of 3-6 months, provides more information regarding progress of disease and recovery of nerve injury.

EMG has been utilized within few weeks of injury to confirm the diagnosis of facial nerve paralysis. However, the more important role of EMG is in chronic diseases to check the viability of muscle before any nerve reconstruction procedures. Fibrillation indicated either nerve block or complete nerve disruption but cannot differentiate the two. In case of chronic muscle paralysis, there will be reduction in amplitude and duration of motor unit potential. Evoked EMG (EEMG) is well utilized in acute paralysis but have not been well understood for chromic paralysis. In this technique, the electrodes are put on the nerve fiber and nerve is stimulated. Simultaneously the electrodes are put on the surface of muscle to detect the response. EEMG done on affected and normal side to proportionally study the degree of blockage.

In addition, various imaging studies like CT scan, MRI and X-rays can be helpful to study the associated problems and lesions leading to facial nerve paralysis.

Management of Facial Nerve Paralysis:

Neural procedures:

Neural procedures involves repair of nerve in various manners. The neural procedures are best done in acute phase or before atrophy of muscles. There are different types of procedures are involved for management of facial nerve paralysis.

- *Nerve decompression:* This procedure is indicated for decompression of nerve in middle year for Bell's palsy. Fosch **[3]** mentioned that decompression is indicated if EEMG reaches 95% within 2 weeks. In rare cases of trauma decompression of nerve is indicated. For long standing facial nerve decompression, the outcome are erratic and anecdotal.
- *Neurorapphy:* It is primary repair of nerve following complete severance.

The nerve is approximated either by suturing or gluing the nerve ends together. The timing the most crucial and best done immediately or in few weeks of injury. The commonly used procedure is

epineural repair under microscopic magnification. It is ensure that orientation of nerve is proper by adjusting various fascicles (Fig. 4).

- *Nerve graft:* When injury is more extensive or late, and gape between two ends of nerve exceed more than 3-5cm, it is advisable to use nerve graft. In facial nerve injury, the nerve grafts are usually done for extracranial route.

The commonest indication is facial nerve excision following malignant parotid gland tumour excision. The proximal and distal ends are marked. The commonest nerve graft material is taken either from sural nerve or great auricular nerve. It is ensured that orientation of nerve graft is reversed. Various other material line vein conduit, collagen splints and fallopian tubes, but have shown variable results. Fisch **[4]** has recommended two graft, one of the upper and another to lower division. During nerve graft, the important braches like frontal, zygomatic, oral branches are given priority. While the other braches like buccal, platysma and other cervical branches are left without repair (Fig. 5).

- *Facial nerve crossover grafting:* This is unique procedure utilized in facial nerve paralysis. This philosophy is evolved due to unique motor fibers which not only provides voluntary motor action but also emotional expression. And therefore reinnveration can produce normal mimetic function. This procedure should be done as early as possible, if the proximal nerve end of the same side is not approachable. The long nerve graft are put across the face, and donor nerve are selected from the normal facial nerve (Fig. 6).

It is advantageous to have multiple crisscrossing and networking of facial nerve braches after the main two division. Taking advantage of this anatomy, the some of the branches are taken as donor nerves without compromising the functions of normal side. The nerve grafts are usually very long taken from sural nerve and crosses the face either in forehead, upper or lower lip. Usually two or more crossover nerve graft are used to provide adequate fibers. These nerve graft are parked on the opposite side and followed-up to see the progress of Tinnel sign. After 6-8 months, the nerve grafts are explored and intraoperatively confirmed that the nerve ends have reached in these graft. After confirmation, these nerved ends are sutured to the paralysed selected nerve braches in specific areas to achieve movement and symmetry.

- *Facial nerve corss over and free muscle transfer:* Occasionally, if the paralysed muscles are atrophied then these nerve fibers are planted in newly transferred new muscle mass by free tissue transfer. The commonly free microvascular muscle transfers are gracilis muscles, pectoralis minor muscles or rarely rectus abdominis muscle.
- Nerve transfer procedure: In special situation, when facial nerve cross over is not possible, like old age, associated morbidity or patient do not want long procedure, then nerve transfer is selected as procedure of choice. These are easy procedures and nerve or part of nerve is trasfered to the distal end of facial nerve.

The donor nerves are hypoglossal and accessory nerve which are located close to the facial nerve. The procedure involved is division of the donor nerve as far distally as possible and transfer the cut end to the facial nerve. In more conservative procedure only part of the nerve is utilized as donor fibers to preserve the continuity of the donor nerve. Jump graft are most popularly used where nerve graft are suture from part of donor nerve to the facial nerve (Fig. 7). Though these are simple procedure with quick results, the movement is mass movement. The movement of facial muscles if related to tongue movement in case of hypoglossal nerve transfer or neck movement in case of accessory nerve transfer. After the surgery, it is essential that patient undergo training session to achieve symmetry at rest and while smiling.

Muscle procedures:

Transferring neuromuscular unit to improve the tone and facial movement is known concept for any nerve/muscle injury. This procedure is usually performed when muscle is atrophied and it is unlikely of regaining function of muscles. Recently Robin **[5]** and Conley **[6]** has popularized thee techniques. The indications are:

- Long standing of more than 3 years duration and unlikely that any neural procedure can be done.
- Distal facial musculature unavailable for neural procedure.
- Contraindication for neural procedure.
- Partial paralysis of upper lip elevator.

There are two specific areas which are consider for muscle procedures. Eyelid reanimation and upper lip reanimation. The results following eyelid reanimation are not very good and therefore mainly oral reanimation is considered. The two main muscles used for upper lip reanimations are temporalis and masseter muscle. Rarely these procedure combined with other neural procedures or muscle procedures.

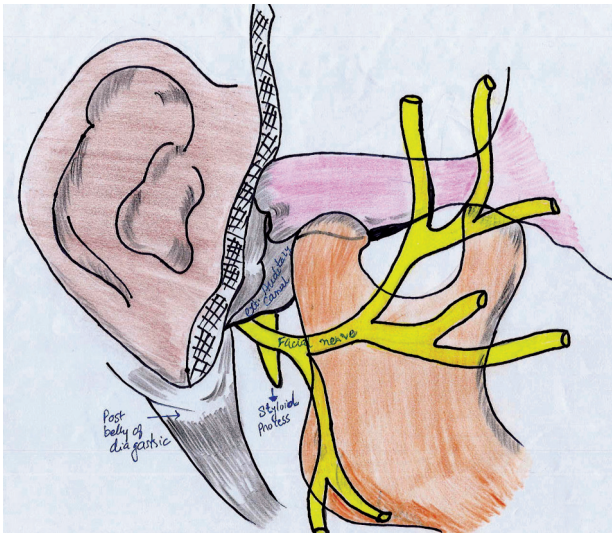

Fig. (1): Extratemporal course of facial nerve, coming out lateral to styloid process.

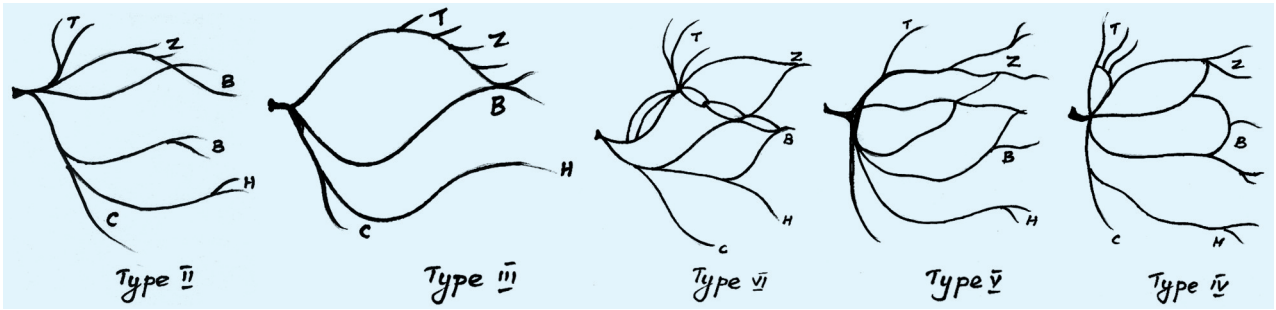

Fig. (2): Variation in branching of facial nerve different types ranging from type II to IV. The figures show various interconnection of braches of facial nerve.

Fig. (3): Different types of depressor of lower lip and angle and deformities due to active muscle on normal side.

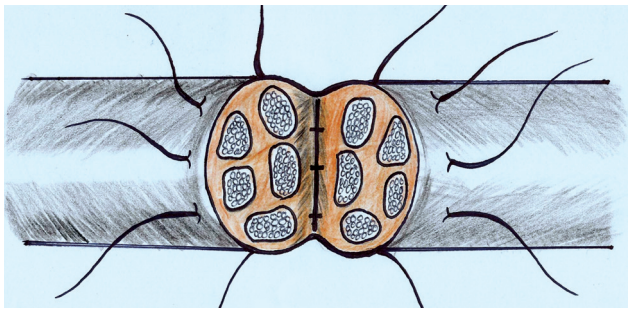

Fig. (4): Primary repair of nerve matching fascicles of nerve, epineurium repair.

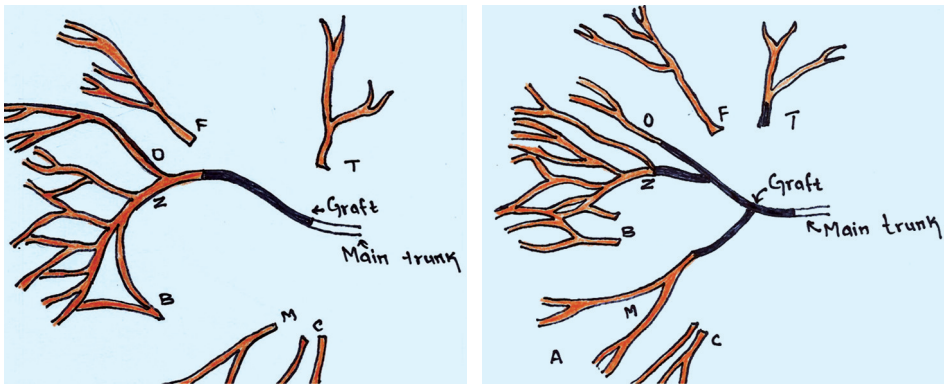

Fig. (5): Nerve graft after partial excision of nerve, either for one important branch or main trunk and multiple branches.

Fig. (6): Multiple facial nerve cross over graft for facial paralysis.

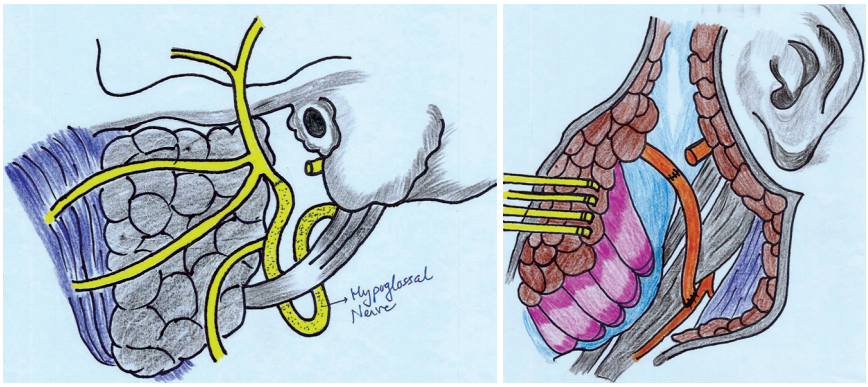

Fig. (7): Nerve transfer either complete nerve transfer to facial nerve or jmup graft where graft is sutured between hypoglossal nerve to facial nerve stump.

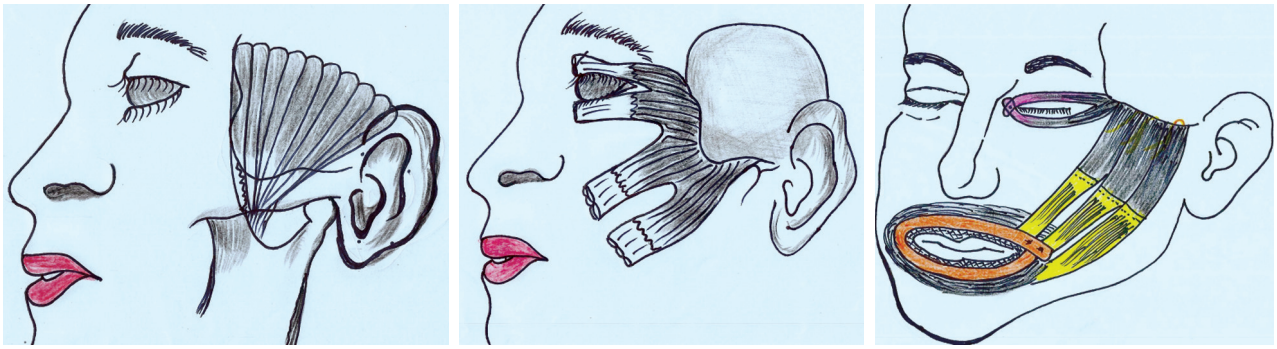

Fig. (8): Temporalis muscle transfer, either as multiple slips to eye and oral commissure or whole muscle transferred to oral commissure with periosteal extension.

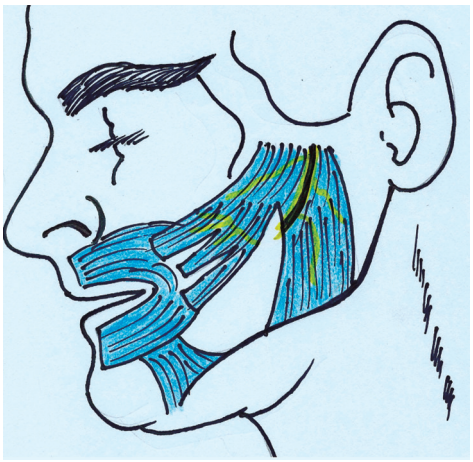

Fig. (9): Anterior half of masseter muclse has been transferred for reanimation of angle mouth.

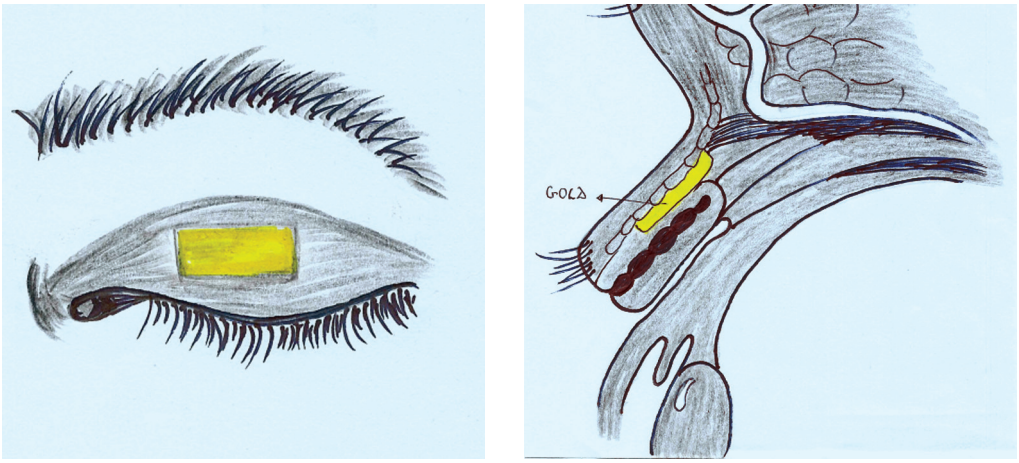

Fig. (10): Insertion of gold in upper lid, just anterior to tarsal plate.

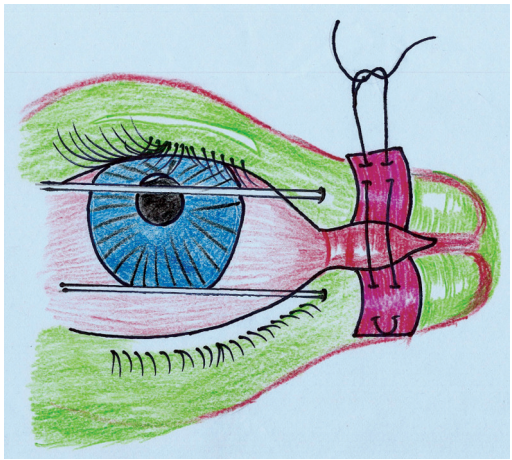

Fig. (11): Lateral tarsorraphy, where edeges are made raw and sutured togather.

- *Temporali transfer:* Temporalis muscle is innervated by mandibular branch and usually un affected in facial nerve paralysis. The muscle is dissected through incision in temporal region hidden in the hair. The muscle either fully or partially raised with upper end periosteal extension. The muscle is divided in different slips and reflected back across the zygomatic arch to various region. The anterior slip goes to eyelids, the middle one to upper lip elecvator and most posterior fibers for angle of mouth and lower lip.

There is always over correction of the deformities are done.

The disadvantage of this procedure is it create hollow in the temporal region and bulging across the zygomatic arch where muscle crosses the arch. To minimize this deformities, the partial temporalis muscle is used in stead of complete muscle or small part of zygomatic arch is removed to reduce the bulge (Fig. 8).

- *Masseter muscle transfer:* Masseter muscle is exposed either through Risdon incision or intraoral incision. The anterior half of muscle is erased.
- *From its insertion on the mandible:* Careful dissection done upto zygomatic arch without injuring the nerve and blood supply. Muscle then transferred for animation of angle of mouth (Fig. 9).

Static procedures:

Static procedure are done to improve the symmetry at rest, but does not help much improvement with movement. They are either done for upper eyelid by putting gold or improve the angel mouth position by sling surgeries.

- *Static sling surgeries for commissure:* In this procedure the slings are prepared either by tensor fascia lata graft or gortex or any other synthetic grafts. One end is fixed to temporal fasia and other end is divided into to or three division. After tunneling this graft through the soft tissue of face, it is sutured to angle of mouth, upper and lower lip through small incision.
- *Gold weight for upper eyelid:* This is a procedure done to improve the position of upper eyelid. Following facial nerve paralysis, there is imbalance of forces in upper eyelid.

The elevator of eyelid are normal while the depressor or muscle closing the eye are weaker (Fig. 10). The upper eyelid is made heavier by insertion of gold piece which by gravity becomes heavier and elevator finds it difficult to elevate the eyelid. This is simple procedure and normally done under local anesthesia. Small incision made in upper eyelid crease and skin and muscles are cut. Anterior surface of tarsal plate is exposed and gold

plate si sutured to tarsal plate by unabsorbable stitches. Skin and muscle are repaired.

- *Tarsorraphy:* It is simple procedure done in facial paralysis to protech eyeball. It is specially indicated in elderly patients when there is hypotonia of lower lid and drooping of lower eyelid. Lateral 4-5mm of lid's edges are made raw and stitched together. This will reduce the size of palpebral fissure and helps to protect the eye ball (Fig. 11).

Conclusion: Facial paralysis is one of the common problem leading to facial deformation. There are many procedures has been described to achieve the symmetry of face at reset, mimetic function and symmetry while animation and protection of eyeball. Different combination are selected to suit individual patient according to the extent of problem and feasibility of the procedures.

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