EARLY REVIEW OF SHOULDER ARTHRODESIS IN BRACHIAL PLEXUS INJURY

By

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DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF MEDICINE (ORTHOPAEDICS)

UNIVERSITI SAINS MALAYSIA

2016

ACKNOWLEDGEMENT

I would like to express my sincerest gratitude to all whom directly and indirectly had been involved and making this dissertation a reality. This work would not have been possible without support and encouragement from all of them. Special thanks to my supervisor, Associate Professor Dr. Abdul Nawfar Sadagatullah, senior lecturer and specialist of orthopedic, for his guidance and constructive criticism throughout the process of producing this dissertation.

Special thanks to Professor Dr. Mohd Imran Yusof as the head of department of orthopaedic Hospital University Sains Malaysia for his support and encouragement.

For valuable help and teaching in the statistical analysis, I would like to thanks miss Hazwani. Without her help, it would be difficult to produce informative dissertation.

Last but not least, million thanks to my parent for their continuous support and encouragement to complete this dissertation.

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BPI	Brachial Plexus injury
MVA	Motor vehicle accidents
DCP	Dynamic compression plate
QuickDASH	Quick Disability of the Arm, Shoulder and Hand
DASH	Disability of the Arm, Shoulder and Hand
ADL	Activities of daily living
HRQoL	Health related quality of live
PCS	physical component summary
MCS	Mental component summary

Abstrak

Pengenalan:

Kebanyakan kecederaan pleksus brakial berlaku akibat kemalangan jalan raya. Kecederaan saraf pleksus brakial akan membawa kepada kecacatan dan dalam jangka masa panjang, memberi tekanan psikologi kepada individu tersebut. Kecederaan pleksus brakial selalunya akan menyebabkan kelumpuhan anggota lengan, deria rasa kulit yang terjejas dan mungkin juga kesakitan pada anggota tersebut. "Arthrodesis sendi bahu" merupakan salas satu cara dapat membawa kepada pemulihan fungsi anggota lengan pesakit. Kajian ini dilakukan dengan tujuan untuk menilai pemulihan fungsi anggota lengan pesakit yang terlibat dengan kecederaan pleksus brakial, setelah rawatan pembedahan "*arthrodesis sendi bahu*".

Kaedah:

Sebanyak 22 orang pesakit telah diambil sebagai kumpulan ujikaji. Kumpulan ini terdiri daripada pesakit yang mengalami kecederaan pleksus brakial dari Januari 2010 sehingga Disember 2013. Kesemua pesakit ini juga telah menjalani pembedahan "*arthrodesis sendi bahu*". Pada akhir kajian, hanya 18 orang pesakit sahaja yang masih tergolong dalam kriteria kumpulan ujikaji. Mereka dinilai mengikut skor kesakitan, fungsi anggota lengan *(Borang Soal Selidik QuickDASH)*, dan evaluasi kesihatan umum *(Borang Soal Selidik SF36v2)* semasa pesakit menghadiri temujanji susulan di klinik.

Keputusan:

Pembedahan "*arthrodesis sendi bahu*" dapat membawa kepada pengurangan tahap kesakitan dikalangan pesakit kecederaan pleksus brakial dengan signifikan.

- Kebanyakan pesakit (66.6%) mengalami kesukaran sederhana untuk melakukan aktiviti fungsional anggota lengan (dinilai melalui Borang Soal Selidik QuickDASH)
- Kesemua pesakit (100%) mencapai markah bawah purata dalam PCS dan hanya 3 pesakit (16.7%) sahaja mencapai markah markah atas purata (>50) dalam MCS
- Sebanyak 16 orang pesakit (88.9%) mencapai penyatuan radiologikal *(radiological union)* dan hanya 2 pesakit sahaja (11.1%) gagal mencapai penyatuan radiologikal.

Ini menunjukkan bahawa, tiada hubungan signifikan antara peyatuan radiologikal dan hasil soal selidik aktiviti fungsional anggota lengan (QuickDASH) serta evaluasi kesihatan umum (SF36v2).

Walaupun majority pesakit mencapai markah bawah purata bagi evaluasi kesihatan umum (SF36v2), kesemua mereka berpuas hati dengan hasil rawatan pembedahan "*arthrodesis sendi bahu*".

Kesimpulan:

Pembedahan *"arthrodesis sendi bahu"* mampu membawa kepada pengurangan tahap kesakitan bagi pesakit yang mengalami kecederaan pleksus brakial. Walaupun majoriti pesakit mengalami kesukaran melakukan aktiviti fungsi anggota lengan (QuickDASH) dan mencapai markah bawah purata bagi evaluasi kesihatan umum (SF36v2), kesemua mereka berpuas hati dengan hasil pemulihan setelah menjalani pembedahan. Malahan, pembedahan *"arthrodesis sendi bahu"* ke atas pesakit yang mengalami kelumpuhan keseluruhan anggota lengan (flaccid) juga dapat memberi kestabilan kepada sendi bahu, sekaligus dapat menyumbang kepada aktiviti fungsi anggota lengan dan meningkatkan kualiti hidup pesakit.

keywords: arthrodesis sendi bahu, kecederaan pleksus brakial, QuickDASH

Abstract

Introduction:

Traumatic brachial plexus injury commonly occurs due to road traffic accident, it often leads to long term devastating disability and psychological stress to the affected individual. The injury leads to flail upper limb, impaired sensation and disabling pain. Shoulder arthrodesis is one of the treatment options that improved upper extremities functional outcome. This study intended to evaluate functional outcome of brachial plexus injury after shoulder fusion.

Methods:

A group of 22 patients with traumatic brachial plexus injury who undergone shoulder fusion from January 2010 until December 2013 were selected. In the end 18 patients were included as study subjects. All selected patients were evaluated for pain score, functional assessment using QuickDASH questionnaire, and General well-being using SF-36 questionnaire during recent clinic follow up.

Results:

Shoulder fusion achieved significant reduction in pain among BPI patients . Most of the patient (63.2%) experience moderate difficulty of upper limb function after evaluated with QuickDASH questionnaire. All the patient achieved below average score in Physical Component Summary (PCS) and only 3 (16.7%) patients achieved score average (> 50) in Mental Component Summary (MCS). 16 (88.9%) patients achieved radiological union and only 2 (11.1%) patients had non-union.

There were no significant correlation between radiological union and (QuickDASH) functional outcome or (SF36v2) general well-being in this study. Although majority of patient's general health (SF36v2) score below average, they were satisfied and had no regret to undergone shoulder fusion surgery.

Conclusions:

Shoulder arthrodesis was able to reduce pain in BPI patients. Although majority of patient experience moderate difficulty in upper limb functional score and below average general health score. Most patients were satisfied with the surgery done. Shoulder arthrodesis helps stabilised the shoulder joint which improved control of upper limb function and lead to better quality of life.

Keywords: shoulder arthrodesis, brachial plexus injury, QuickDASH

CHAPTER 1 - Introduction

Brachial plexus injury (BPI) commonly occurs from high speed motor vehicle accident, but it may follow lesser injury such as falls. Severity of the injuries can vary and often cause devastating injuries that lead to significant long term functional disability, face socioeconomic difficulties and cause psychological stress to the individual and family. Treatment in brachial plexus injury depend on the severity and duration of the injury. Many patients can have functional improvement through early surgery to the plexus which including exploration, neurolysis, nerve grafting, or nerve transfer. Patient with root avulsions or those fail to recover following surgery maybe left with flail shoulder. This affects shoulder stability and makes independent positioning of the hand in space difficult. Post traumatic brachial plexus Injury results in flail upper limb which can be both painful and non-functional. Shoulder arthrodesis is a choice for treatment and it is indicated in situation to provide pain relief and increased functional stability.

In the past, it was essential to have normal motor and sensory function of the hand and elbow before performing a shoulder arthrodesis (Barr et al, 1942: Ransford et al, 1977). Indication for shoulder arthrodesis include post traumatic brachial plexus injury, paralytic disorders in infancy, severe refractory instability, chronic infection, failed revision shoulder arthroplasty, rotator cuff insufficiency and bone deficiency following tumour resection of proximal humerus (Chandler et al, 1991). In order to gain a good functional outcome after shoulder arthrodesis, scapula stabilizing muscle assessment is essential prior to surgery. These muscles are required to provide motor function to the extremities. These groups of muscle are trapezius, levator scapulae, serratus anterior, latissimus dorsi and rhomboid muscles. Several literatures reported success of shoulder arthrodesis in brachial plexus injury patients (Clare et al, 2001).

Many technique for shoulder arthrodesis are proposed and can be divided into extra-articular (acromiohumeral), intra-articular (glenohumeral) or combination of both. Many literatures reported successful method would be combination of intra- and extra-articular method with stabilisation utilising internal fixation. However, every surgical procedure has it complication. Among the complication of shoulder arthrodesis were non-union, malpositioning of the fused shoulder, perifusion fractures, infection, continued pain and soft tissue irritation caused by prominent fixation devices. Shoulder arthrodesis is a well established procedure in orthopedic surgery, but over the years the indication for this surgery has narrowed. It has proved to provide satisfactory pain relief, a stable shoulder and improved function (Clare et al, 2001)

In this study, we would like to assess functional outcome after shoulder arthrodesis in brachial plexus injury patients. More objective measure will be employed to assess functional and general condition of the patients after glenohumeral arthrodesis.

CHAPTER 2 - Literature Review

2.1 Epidemiology:

Brachial plexus is a network of nerves which originate from the ventral rami of C5 to T1 spinal nerve root that innervate muscle and skin of upper extremities. Injury to the brachial plexus is relatively common due to traumatic motor vehicle accident and subsequently lead to traction or compression to the nerve plexus. Other causes of brachial plexus palsy occurs from obstetric birth trauma, tumour compression, penetrating injury or irradiation to the base of neck. Brachial plexus injury can be divided into complete, upper or lower trunk injury.

Current available data for traumatic brachial plexus injury in adult are still insufficient and the exact incident is still unknown. Most countries reported brachial plexus injury occur in 1% of multiple trauma. Young male were disproportionately affected, mostly between 15 to 25 years of age. On the basis of 18 years of experience with1068 patients, Narakas developed his rules of "sev-en seventies" as follows (Narakas et al, 1985).

- Approximately 70% were motor vehicle accidents (MVAs)
- Of the MVAs, 70% were motorcycles or bicycles
- Of the cycle riders, 70% had multiple injuries
- Of the multiple injuries in cycle riders, 70% were supraclavicular injuries
- Of the supraclavicular injuries, 70% had at least one root avulsed
- Of the avulsed roots, 70% were lower C7, C8, T1
- Of the 70% avulsed roots, 70% of those were associated with chronic pain.

Generally, traumatic brachial plexus injury can be classified based on the location of lesion which is upper trunk, lower trunk or complete plexus injury. Most common type of injury were total (pan) brachial plexus injury which account for 75-80%, upper trunk (Erb palsy) only 20-25%, and the rest affecting lower trunk (klumpke palsy) of traumatic BPI (Miller et al, 2012).

2.2 Type of injury:

In traumatic BPI, the lesion of nerves in the brachial plexus may be stretched, ruptured, or avulsed from the spinal cord (Figure 2-1). The extent and location of the injury were variable, it determines the prognosis of recovery. In tractional injury, the nerve is stretched but not torn from the spinal cord. The degree of injury may vary from mild forms where all neural element and structures are intact (neurapraxia) or disruption of only axons with intact supporting structures (axonotmesis) to a more severe form where the entire nerve along with its supporting layers is ruptured (neurotmesis). Lesion that are in continuity (neuropraxia/axonotmesis) have potential for spontaneous recovery without surgical intervention. Whereas, more severe neural lesion such as ruptured or avulsed neural elements (neurotmesis) require surgical treatment to improve nerve function (Spinner et al, 2005).

Traumatic BPI can be either Pre-ganglionic or post-ganglionic, depending on the location of nerve injury. Pre-ganglionic injuries occur proximal to the dorsal root ganglion and can be central avulsion, in which the nerve is torn directly from the spinal cord. A peripheral avulsion (intradural rupture), is when the injury is proximal to the dorsal root ganglion but remnants of the root remain attached to the spinal cord. Avulsions commonly affect both the dorsal and ventral roots together, but may affect the dorsal or ventral roots alone in as many as 10% of cases (Oberle et al, 1998).

The dural sac may be ruptured, producing a pseudomeningocele in MRI or CT myelogram, characteristic of a preganglionic injury. Post-ganglionic lesion occur distal to the dorsal root ganglion. It involved mostly peripheral nervous system and are capable to regenerate, hence it has better prognosis (Cavalho et al, 1997)

Other than the lesion described above, it can also be described according to the location of lesions such as supraclavicular, infraclavicular and retroclavicular. Supraclavicular injuries were shown to be more common (72%) and more severe compared to infraclavicular injuries. Common patterns of supraclavicular injury include total, upper trunk or lower trunk injury. A complete plexus injury (C5-T1) may lead to flail limb and insensate hand. An upper trunk (C5/C6) pattern loss is notable for absent shoulder abduction, external rotation, and elbow flexion. The upper pattern may include C7 injury in a number of patients, and this may be manifested by weakness of the triceps, pronator teres, and wrist and finger extensors. Lower trunk injuries (C8/T1) typically include Horner syndrome, loss of hand intrinsic and extrinsic function, but preserved shoulder and elbow motor function (Spinner et al, 2005).

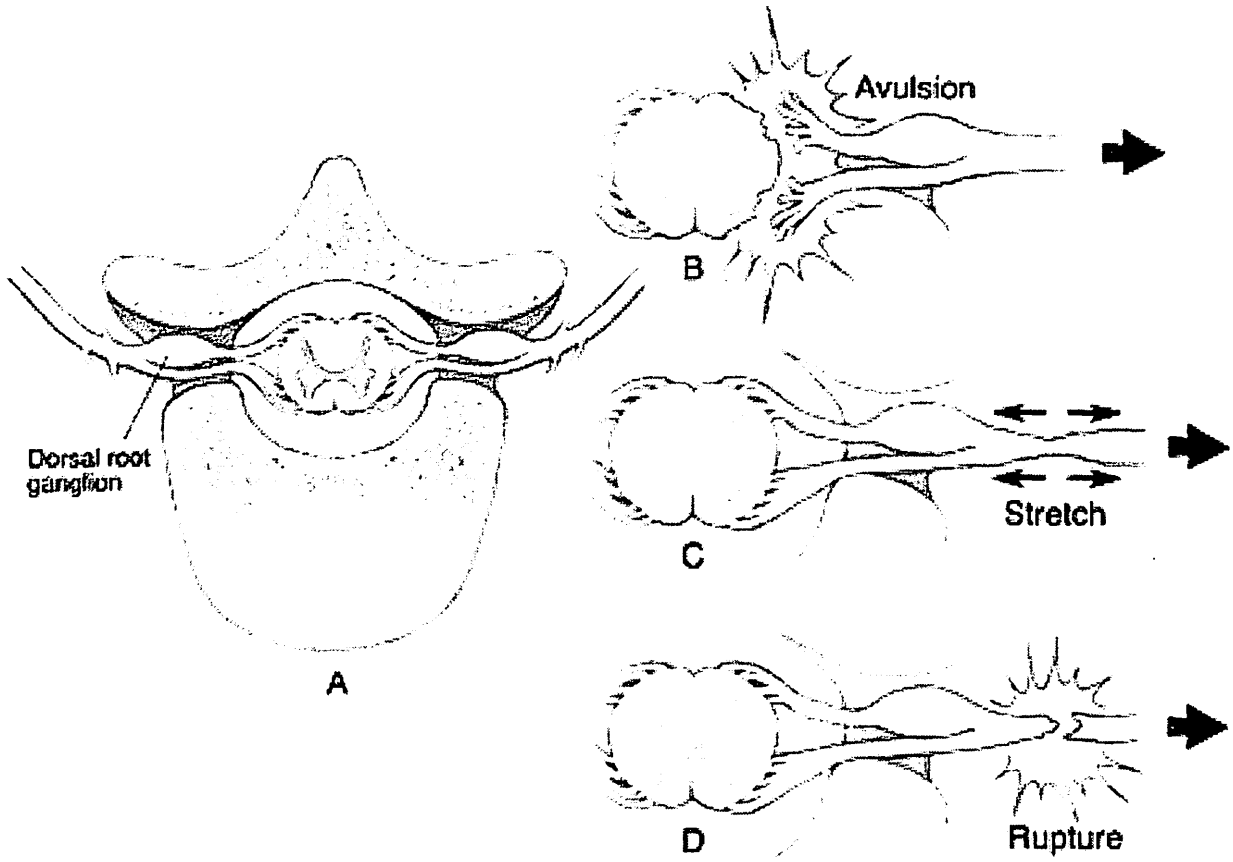

Figure 2-1: Traumatic lesions of the brachial plexus. Traction of the individual nerves or nerve roots of the brachial plexus (A) may result in injuries of varying magnitude resulting in avulsion (B), stretch (C), or rupture (D). Image obtained from Spinner et al, 2005

2.3 Evaluation of the patients:

Majority of the BPI patients were associated with multi-trauma. Potentially life threatening co-existing trauma to the head, chest, abdomen, pelvis and spinal cord should be prioritised, but the diagnosis of peripheral nerve injury should still be established and manage accordingly. A detailed history and thorough physical examination which help to diagnose brachial plexus injury as important. With recent advance in investigation such as MRI, more detail localisation is necessary. Lesions can be localised to specific neural element and more precisely to the location of avulsed nerve root, pre- or post-ganglionic (Shin et al, 2005)

History need to focus on mechanism of injury with relative position of the neck, trunk and upper limb. Presence of associated fractures would predict the neurological lesion and influence the outcome of recovery. Physical examination should concentrate on identifying the extend of neural deficit and anatomic localization for the dysfunction. A baseline neurologic examination is essential to assess the progress of neurological recovery. Examination includes inspection (for muscle atrophy), testing, and grading of each nerve motor and sensory function. Presence of Horner syndrome or winging of scapula (rhomboid and serratus muscle paralysed) would be suggestive of a preganglionic injury. Presence of tinel sign that is strong over neck immediately after injury would be suggestive of a rupture. The absence of it is suggestive of an avulsion. Besides that, concomitant vascular status, musculoskeletal injury or fractures need to be examined and shoulder range of motion should be documented (Gilbert 2001)

In addition to history and physical examination, several investigation such as imaging studies (radiograph, CT scan or magnetic resonance imaging) as well as electrodiagnostic studies (nerve conduction study and electromyography) should be included in a patient's workup for brachial plexus injury. Presence of transverse or spinous process fractures in cervical radiographs might be suggestive of a preganglionic injury. Shoulder and chest radiographs rule out concomitant fractures of the upper extremity or clavicle as well as hemiparesis of the diaphragm (phrenic nerve injury). Electrodiagnostic study help establish a localization and determine the severity of a lesion. It is best performed 2 to 3 weeks after injury because denervational changes from Wallerian degeneration require several weeks to develop. CT or MR myelography are preferred imaging modalties for accurate visualisation of intervertebral foramina, anterior and posterior rootlet, thus determining the presence of preganglionic lesion (Spinner et al, 2005)

2.4 Management:

Generally, Patients with brachial plexus lesions (neuropraxia) were observed for spontaneous recovery. During this period, serial clinical examination and electrodiagnostic test should be performed to gauge neurologic recovery. Passive joint movement should be encouraged to prevent stiffness or joint contractures and to strengthen functioning muscles group in the affected limb. Patients with any sign of recovery and those with partial lesions can be treated non-operatively (Gilbert 2001).

2.4.1 Timing of surgery:

Those patients without evidence of clinical or electrical recovery by 3 to 6 months should undergo operative intervention. Poorer outcomes was associated in patients who underwent nerve procedures after 6 months. Nerve surgery is not advisable after 1 year due to irreversible motor end-plate degeneration, muscle atrophy and neuronal death which prevent meaningful reinnervation. However, some patients who turn up late to seek for treatment, other operative procedure can still be perform for either reconstruction or pain management. (Spinner et al, 2005)

2.4.2 Surgical treatment option:

Primary treatment of brachial plexus injuries includes nerve repair, nerve grafting, extraplexal or intraplexal (plexoplexal) neurotization, and free muscle transfer. Priorities include elbow flexion, shoulder stabilization, hand protective sensation, then grasp (wrist extension, finger flexion), release (wrist flexion, finger extension), and intrinsic function. In the past, shoulder abduction, elbow flexion, and hand sensibility have been obtained in many cases, but new surgical techniques continue to improve outcomes of extremities functions, allowing them to be succeed more frequently (spinner et al, 2005)

Direct nerve repair usually is perform in those who sustained acute sharp injury with nerve transection. It is least possible to perform in avulsion type of injury. Other than that, surgical advances in brachial plexus surgery have been most apparent in the introduction of new nerve transfers (neurotization). Neurotization can be performed in cases of preganglionic or combined preganglionic and postganglionic injury. Root avulsions, long considered to be irreparable, are by no means

unreconstructable. In addition, neurotization are being used to provide more rapid and reliable recovery of specific limb functions. Nerve transfer were derived from extra or intraplexal source. Widely used extraplexal neurotization sources include the intercostal and the spinal accessory nerves. These nerves can provide good functional recovery and can be sacrificed with lower morbidity at the donor site. Newer extraplexal sources include the ipsilateral phrenic nerve and contralateral C7. These nerve transfers have been introduced to expand on the limited donors. These technique has given the opportunity to reconstruct additional targets or reinnervating more distal targets to give better functional outcomes. (Gu et al, 1992; Songchroen et al, 2001)

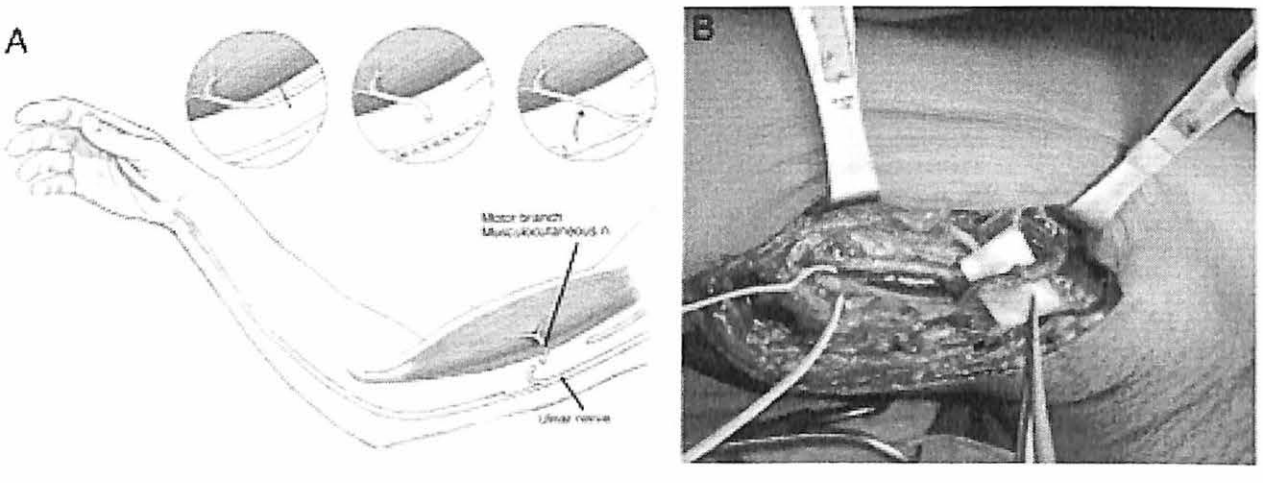

Figure 2-2 illustrates Oberlin procedure, 1 fascicle from the ulnar nerve that supply flexor carpi ulnaris (wrist flexion) were transferred to motor branches of musculocutaneous nerve that supply biceps brachii muscle (elbow flexion). Image obtained from Spinner et al, 2005

Recent introduction of Intraplexal sources have gained increasing popularity, especially in patient with upper plexus injury. Intraplexal neurotization entails exploiting functional fascicles of working donors. Examples include thoracodorsal or medial pectoral branch to biceps, distal anterior interosseous nerve to deep branch of the ulnar, triceps to axillary, or even ipsilateral C7.

Another technique of fascicular transfer was described by Oberlin et al.(Figure 2-2). One fascicle from ulnar nerve that supply the wrist flexor can be used for direct apposition to the motor branch of biceps brachii muscle (Oberlin et al, 1994). It is indicated for upper trunk injury with C5/C6 avulsions and some might extend to perform in cases of C5/C6/C7 injury. One of the advantage in this procedure was a significantly shortened distance and duration for re-innervation. Patients may show early recovery by 3 months and regain good elbow flexion by 6 months.

Free functioning muscle transfer is another option, it has been used to recontruct elbow flexion, occasionally coupled with wrist extension (Akasaka et al, 1990). It is usually performed in patients who presented late when irreversible muscle atrophy has occurred.

2.5 Shoulder arthrodesis in Brachial Plexus Injury

When the above mentioned surgical treatment were not feasible in BPI patients (due to extensive injury or late presentation), shoulder arthrodesis is a choice to stabilise the shoulder. A flail shoulder makes it difficult to gain control and makes independent positioning of the hand in space. Post traumatic BPI results in flail upper limb which can be both painful and nonfunctional. Glenohumeral joint arthrodesis serves as an important treatment to stabilize a paralyzed shoulder in adults when limited options are available. It is indicated in situation to provide pain relief and increased functional stability (Safran et al, 2006). Current studies were carried out to assess the functional outcome of BPI patient after shoulder arthrodesis.

2.5.1 Indication for shoulder arthrodesis.

In the 20th century, shoulder arthrodesis was a relatively common procedure. It was mainly performed for paralytic shoulder caused by polio or tuberculosis joint destruction. Because the procedure was so successful, the list of indications expand over several decades. It is essential to have normal motor and sensory function of the hand and elbow before performing a shoulder arthrodesis (Barr et al, 1942: Ransford et al, 1977). Indication for shoulder arthrodesis include post traumatic brachial plexus injury, paralytic disorders in infancy, rotator cuff insufficiency, chronic infection, failed revision arthroplasty, severe refractory instability and bone deficiency following tumour resection of proximal humerus (Chandler et al, 1991). To achieved good functional outcome after shoulder fusion, it is important to assess scapula stabilizing muscle prior to surgery. These muscles are required to provide motor function to the extremities. These groups of muscle are trapezius, levator scapulae, serratus anterior, latissimus dorsi and rhomboid muscles. Several literatures reported success of shoulder arthrodesis in brachial plexus injury patients (Safran et al, 2006).

2.5.2 Contraindication for shoulder arthrodesis.

The contraindications to shoulder arthrodesis include paralysis of the trapezius, levator scapulae, serratus anterior, latissimus dorsi, or rhomboid muscles. Richards reported that, if scapula stabilizing muscles are non-functional, the extremity will be severely impaired despite successful joint fusion (Richards et al, 1995). Charcot arthropathy has also been reported as a contraindication to shoulder fusion due to a higher rate of nonunion and infection, thus it was discouraged (Wilde et al, 1987). Another contraindication to shoulder arthrodesis is a contralateral shoulder arthrodesis. Bilateral shoulder arthrodesis severely inhibits the patient's functional abilities, including the ability to perform activities of daily living.

2.6 Surgical technique

There were numerous techniques for glenohumeral arthrodesis published in literature, it can be are classified into intra-articular(glenohumeral), extra-articular(acromiohumeral), or a combination (Clare et al, 2001). The extra-articular methods described by Putti, Watson Jones, and Brittain were used early in the twentieth century, primarily in treating tuberculosis. Probably the most successful method was to employ a combination of intra- and extra-articular technique and stabilise with plate. Extra-articular bone contact is obtained between humeral head and acromion. Decortication of articular surfaces in humeral head, glenoid, and inferior part of the acromion were important to ensure maximum bone contact and ensure bony union (Clare et al, 2001). In this study, all BPI patients underwent surgical treatment via combination of intra- and extra-articular method to achieve maximum joint fusion.

Besides that, several method has been described using multiple screws, plates, external fixation, or tension-band wiring. Currently the most popular method was AO technique using either a single or double plate for shoulder arthrodesis. Richards et al. used a single contoured 4.5-mm dynamic compression plate (DCP) placed over the spine of the scapula, acromion, and the lateral portion of the humeral shaft for shoulder arthrodesis in his 14 patients and all achieved solid fusion(Richards et al, 1985). Stark et al. used a long DCP in 15 patients undergoing arthrodesis, with no postoperative immobilization aside from an abduction pillow. Fusion was achieved in 14 of 15 patients, and extremity position was lost in only one patient, in whom fixation was inadequate (Stark et al, 1991).

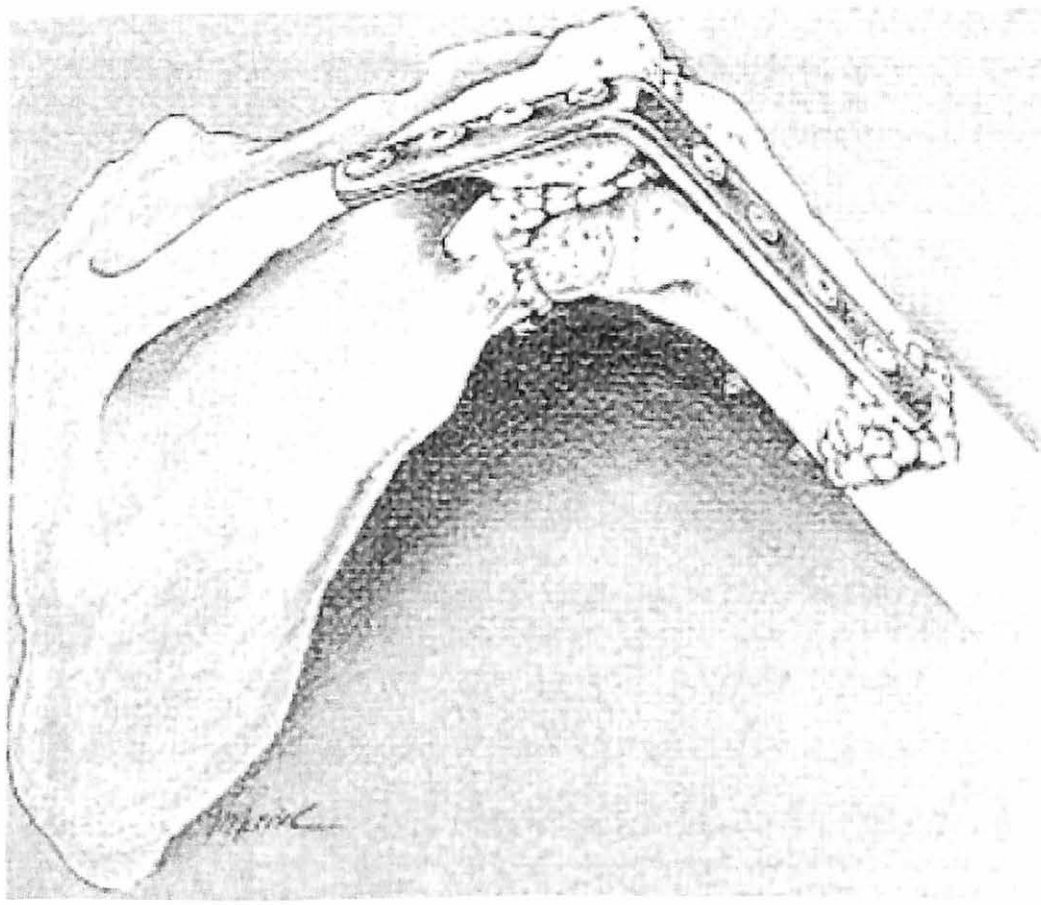

Figure 2-3: Contoured DCP apply along scapula spine, acromion and proximal humerus. Bone graft was inserted in between space in arthrodesis site to achieve better fusion. Image obtained from Chandler et al, 1989

2.7 Shoulder arthrodesis surgical approaches

The AO surgical technique for shoulder arthrodesis is described. Once patient is under general anaesthesia, the patient is placed in the lateral decubitus position. An incision was made along the spine of the scapula and continued to cross over the acromion, and extended distally until proximal third of the humerus. Subsequently, the dissection continued with subcutaneous and periosteal direction to expose the scapular spine, glenoid fossa, and proximal third of the humerus. The articular cartilage of glenoid fossa and humeral head was denuded. The inferior surface of the acromion and the lateral portion of the humerus was decorticated for contact with the acromion. An osteotomy of the acromion may be performed to increase contact between the plate and bones. The humeral head then was put in the desired position in the glenoid fossa. A malleable template is used to determine the contour for a standard broad AO plate and contour the plate with bending press and irons. The plate was placed along the scapular spine, over the acromion, and against the proximal third of the humerus (Figure 2-3).

The plate is then fastened initially with a long cortical screw inserted vertically into the scapular neck. The remaining proximal screws were inserted into the scapula spine. The humerus is compressed superiorly and medially to lie against the acromion and glenoid fossa in the desired position for arthrodesis. The plate is fixed distally with two screws that pass through it and the humeral head and into the glenoid fossa and scapular neck. The remaining screw was inserted into the plate for adequate stability. Iliac bone grafts is applied as desired. The wound is closed in layers over drains. Postoperatively, the patient wears a Velpeau dressing for several days or arm sling for up to several weeks. Light, active exercises are begun 3 weeks postoperatively to improve scapular motion and muscle strength.

Figure 2-4 (left) showed patient's normal upper limb position after shoulder arthrodesis in resting state

Figure 2-5 (right) showed surgical incision made on patient's left shoulder from spine of scapula, across acromion until proximal humerus.

2.8 Rehabilitation following shoulder arthrodesis

Patient who under went shoulder arthrodesis need to follow series of rehabilitation programme in order to gain good shoulder and upper limb function. Special rehabilitation programme aimed at strengthening of periscapular muscle motion.

Figure 2-6 (left) showed patient's Left shoulder abduction after shoulder arthrodesis (50°)

Figure 2-7 (right) showed patient's left shoulder flexion up to 70°

2.9 Complication of shoulder arthrodesis

Many authors advocates the used of internal fixation for maintenance of the position of the arthrodesis both intra-articular (glenohumeral) and extra-articular (acromiohumeral) (Richard et al, 1993). This surgical technique was reported to have a high rate of successful fusion, although complications might occur. Fracture about the shoulder may occur in patient treated with a shoulder arthrodesis. The fracture may occur around the implant or distal to the site of the arthrodesis. Distal fractures have responded to nonoperative treatment with simple use of a sling.

Nonunion rates in recent series are reported to be less than 10%. It may occur after either primary or revision shoulder arthrodesis, but it was rare when current fixation techniques are used concurrent with autologous bone grafting (Groh et al, 1997). To further minimise chances of failure, patients should be counselled preoperatively to abstain from tobacco use because it was linked with increased risk for nonunion. Optimal operative technique includes careful attention to elimination of all cartilage, maximum bone coaptation, and solid positioning of all implants (Clare et al, 2001).

Another possible complication was prominent and painful hardware. In a classic study by Cofield and Briggs, 24% of patients required reoperation for removal of painful hardware (Cofield et al, 1979). Besides that, complication that arise due to malposition of the extremities or winging of scapula which was primarily the result of excessive abduction and flexion, that can lead to dull, painful ache in the shoulder. In addition, excessive abduction can cause suprascapular neuritis due to traction of the nerve. Secondary degenerative arthritis of the acromioclavicular joint is common after arthrodesis.

Possible complication that may arise is surgical site infection. Wound infection at the operative site is managed with standard wound debridement along with tissue culture from the wound. Appropriate antibiotics should be started once diagnosis of infection was established. Similarly, complication from the iliac bone graft donor side may occur such as wound hematoma. This problem can be solve with insertion of drain prior to wound closure ad remove it later once bleeding has stopped. Another possible complication related to the harvest of iliac-crest bone graft is the risk of injury to the lateral femoral cutaneous nerve and the potential development of meralgia paresthetica (Clare et al, 2001).

2.10 Assessment on outcome of shoulder arthrodesis

The outcome of shoulder arthrodesis depend on the type of injury and successful should arthrodesis. Several study published regarding outcome of shoulder arthrodesis in BPI patients did not have proper objective assessment. Most of the studies assess functional outcome subjectively. Emmelot reported good functional outcome and overall improvement in most cases with regard to dressing, cosmetic appearance, physical hygiene, walking, running, and particularly feeling more stable (Emmelot et al, 1997). In this study, we would like to have proper objective assessment pertaining to outcome after shoulder fusion.

2.11 Objective outcome assessment

2.11.1 Functional outcome measurement (QuickDASH)

A simple and commonly used method of objectively assessing upper extremities function is a patient self-report questionnaire. There are several instruments available and four commonly use functional questionnaires for evaluating upper extremity function are the Constant-Murley Shoulder Score (CMS), the American Shoulder and Elbow Surgeons (ASES) Self-Report Form, the University of Pennsylvania Shoulder Score (U-Penn), and the Disabilities of the Arm, Shoulder, and Hand (DASH) or modified version QuickDASH outcome measure.

The disability of the arm, shoulder and hand (DASH) questionnaire is an upper-extremity specific outcome measure that was introduced by the American Academy of Orthopedic Surgeons (AAOS) in collaboration with a number of other organizations (Hudak et al, 1996). The DASH outcomes measure was developed to evaluate symptoms and upper extremity functional status and to determine the relative impact of disorders (Davis et al, 1999). The DASH is a 30-items questionnaire with a five-item response option for each item, self reported questionnaire. A modified version called the QuickDASH is also valid, reliable and responsive and can be used for clinical and/or research purposes. Instead of 30 items, the QuickDASH uses 11 items to measure physical function and symptoms in people with any or multiple musculoskeletal disorders of the upper limb. Both test has a maximum score of 100, where higher scores reflect greater disability. It can be used as either a one-time measure or to determine change over time. These questionnaire has been demonstrated to be a valid and reliable tool for both proximal and distal disorders of the upper extremity, therefore confirming its usefulness for multiple joints of the entire upper extremity (Stiller et al, 2005).

DASH questionnaire measures the impact of disorders on the whole person rather than on a disabled limb. With this in mind, we could use it to measure the level of disability, whole person's ability to function, even if the person is compensating with the other arm or using devices. The DASH and QuickDASH are relatively new tools, at present, there was no definitive category to differentiate mild, moderate or severe level of disability, or to determine whether an individual is not fit to work. The upper extremities work as a single functional unit, DASH is mainly a measure of disability and it is suitable to assess functional outcome. Normative data for the DASH Outcome Measure has been collected in a large general population survey (n=1800) in United State conducted by the AAOS (Hunsaker et al, 2002). In this paper, the mean DASH score for the general population was 10.1. The mean QuickDASH score for the same general population is 10.9. After reviewing a few reported paper, we can roughly conclude and categorise the disability based on the study. A QuickDASH score ranging from 20 to 39 was mild disability, 40-69 was moderate disability, more than 70 was severely disabled. It was just a rough guideline as according to DASH outcome e-bulletin 2013 there were no proper cut-point or benchmark to categorise DASH/QuickDASH scores as indicating mild, moderate or severe levels of disability (Kennedy et al, 2011).

2.11.2 Pain score

Brachial plexus injury not only lead to upper extremities paralysis, it also cause severe pain of the flail limb due to neural element avulsion. When all surgical treatment has failed to relieve chronic pain and shoulder disability, arthrodesis might be the last choice to consider. Although pain may not be completely resolved by arthrodesis, it stabilised the shoulder joint and makes it more comfortable to the patients. If there is a chance of relieving chronic pain and restoring some degree of limb function, arthrodesis warrants consideration (Carter et al, 1983).

However, failure to relieved pain and restore function may cause disappointment. More shoulder fusion studies has reviewed and proven that comfortable anatomic position of the arm in relation to the trunk, patient is considering arthrodesis of the shoulder with much greater optimism. Studies indicate most patients report marked pain relief after surgery, although few are completely pain-free. Hawkins and Neer reported that only 4 of their 16 patients were pain free, whereas 9 needed analgesics on a daily basis for moderate or severe pain (Hawkins et al, 1987). Cofield and Briggs reported better pain control in their series. Of the 65 patients, 25 (38%),were pain free, 24 (36%) had mild pain, 15 (23%) had moderate pain, and only 2 (3%) had severe pain. Of the 17 patients with moderate or severe pain, 10 (59%) had pain located to the surgical area, 5 (29%) had pain in the periscapular region, and 2 (12%) had diffuse pain. Extremity function was limited by pain in most of the patients with moderate or severe pain (Cofield et al, 1979). Rouholamin reported an excellent pain relief in 10 of 15 patients with brachial plexus injury who underwent shoulder arthrodesis. Three patients reported aching with prolonged use of the arm; the pain was relieved with rest. Two patients with preoperatively diagnosed neurogenic pain continued to have pain (Rouholamin et al, 1991). Based on these series, we can conclude that shoulder arthrodesis can provide considerable pain relief among BPI patients. Besides that, pain can affect patient's ADL, ability to work or return to previous job as well as their recreational activities.

2.11.3 Subjective outcome assessment (SF36v2)

Health status among general population are becoming increasingly important. It is directly related to quality of life and become main concern for many people. It is the main target of a health care intervention. The quality of life is encompasses aspects of physical, social, emotional and spiritual well-being. "Health-related quality of life (HRQoL)" has sometimes been preferred to that of quality of life because it concerned primarily with those factors that related to health care system and affected by health (Sararaks *et al.*, 2005).

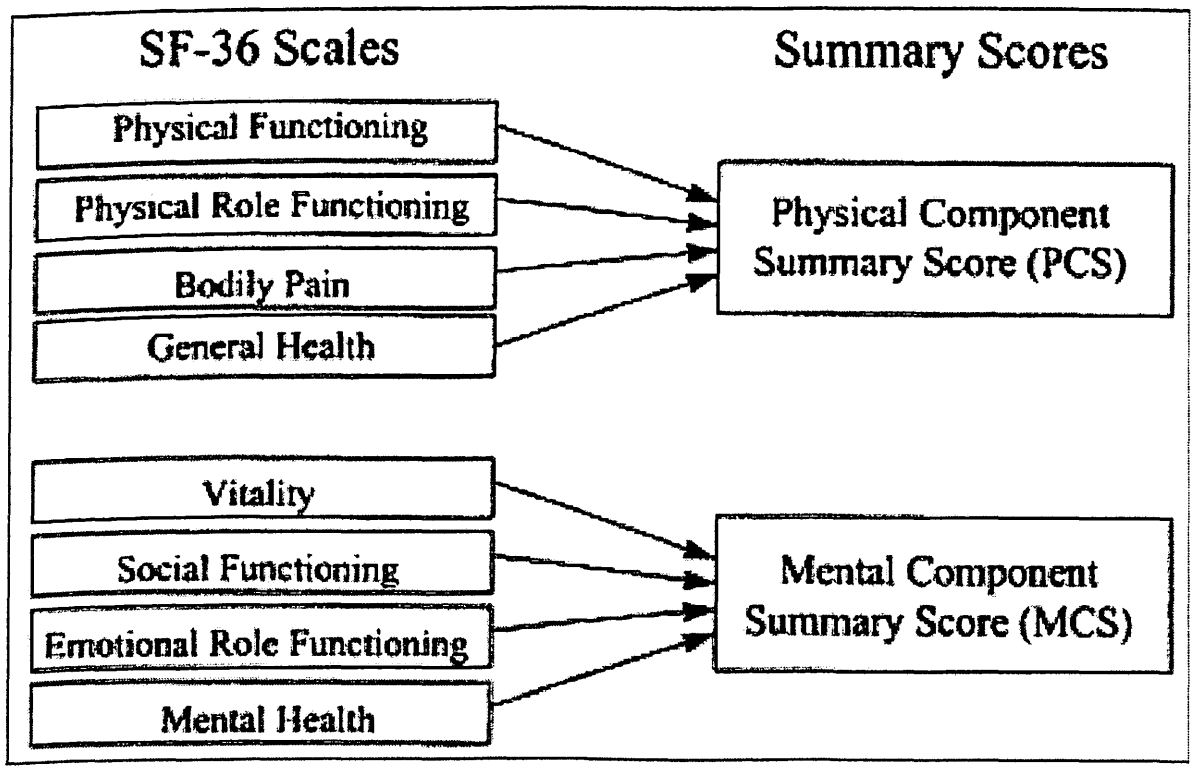

Figure 2-8: Diagram of SF-36 Scales consists of physical component summary score (PCS) and mental component summary score(MCS).

Various assessment tool were available to evaluate HRQoL, and SF-36 Questionnaire is perhaps the most extensively used in the health care system, widely translated and tested instrument worldwide (Ware et al, 1993). SF-36 is a multipurpose, short form health survey which contain only 36 questions. It yields an 8-scale profile of functional health and well-being scores as well as psychometrically-based physical and mental health summary measures (Thomas et al, 2004).

The SF-36 can be either self-administered or administered by a trained interviewer. In 1996, the SF-36 health survey was replaced with the SF-36v2 (international version). It has been used in survey of general and specific populations, for comparing the relative burden of diseases across different subgroups and in differentiating the health benefits produced by health care treatments (Mandeep et al, 2013).

A group of researchers from University of Science Malaysia (USM) translated the UK version of SF-36v2 into the Malay (Bahasa Malaysia) version in 2000. A research team under the aegis of International Quality of Life Assessment (IQOLA) Project had developed a translated version (Sararaks et al, 2005). After cognitive debriefing to further refine the language and terminology used in the main ethnic groups, the Malay version of SF-36v2 has been used as a measurement tool across multiple health conditions in Malaysia (Sazlina et al, 2012; Md Yusop NB et al, 2013; Atif et al, 2014). The Malay version of SF-36v2 has its generally acceptable internal consistency and validity (Sararaks et al, 2005), and is widely accepted.

The SF-36v2 has eight domains, which are represented by the Physical Component Summary (PCS) and Mental Component Summary (MCS). Total mean scores for each domain ranged from 0 to 100, and the higher mean scores suggested the better HRQoL (Ware *et al.*, 1993).