CONTRIBUTION OF SUŚRUTA TO THE FUNDAMENTALS OF ORTHOPAEDIC SURGERY

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Injuries of bone and skin were probably the earliest recorded injuries in medical history since man started methodical treatment of these accidental trauma. In the Suśrutasamhitā (c. 500 B.C.) one finds a vivid description of the classification of various types of skeletal injuries. Their diagnostic criteria have been dealt with in great detail and the general principles of the management are thoroughly described. All these classifications have been compared with the modern classification and principles of management as described and practised in modern orthopaedic surgery.

An effort is made to draw a parallel between the two treatments and highlights. The thoroughness of the approach of Suśruta is also discussed with authentic references from the text. The basic approach to the management of the complications of fracture and importance of rehabilitation with different methods is also examined on the basis of methodology and principles. The paper in short proves the thoroughness of the basic approach of Suśruta in the management of skeletal injuries, which in fact has not changed in principles over the period of 2,500 years, in spite of the advancement of modern orthopaedic surgery.

The history of traumatic surgery is probably as old as the origin of mankind since accidental injuries are the unavoidable incidences and when an injury has been received, it is a natural reflex of every living being to make efforts in the direction of obtaining a quicker and better healing. The word ‘healing’ here denotes not only the process of repair of the wounded tissue but also aims at achieving the maximum working efficiency of the injured part. The importance of obtaining a good working limb is most realized when the accident is big enough to result into a fracture of the bone. The ‘Orthopaedic Surgery’, therefore, initially started with the management of these skeletal injuries.

In India, this type of ‘traumatic orthopaedic surgery’ was practised well before Christ, but it was Suśruta, who is now believed to have lived some time during the third millennium B.C., deserves the credit of classifying skeletal injuries into various groups in respect of their anatomical variations and prognostic values and for ensuring proper management. Elaborate description of this branch of surgery is available in his treatise (popularly known as Suśrutasamhitā). After going through the chapters on bone-injuries in this book, one cannot resist in forming a positive opinion about the most systematic and extensive
study of these cases made by Suśruta. It is true that the methods of management of fractures have now been modified greatly over a period of nearly three thousand years, but the fact cannot be denied that the principles of diagnosis and treatment of these cases laid down by Suśruta still hold good and deserve appreciation. Some of these principles of orthopaedic surgery, as practised by Suśruta, are described here; they speak for the perfection achieved in the principles of surgery in an age when the 'modern medicine' had no existence in any part of the world.

It may be worth mentioning here that the history of modern orthopaedic surgery does not start before Hippocrates who is believed to have been born about 460 B.C. in the Island of Cos, and died about 370 B.C., at a much later period than Suśruta. Though there are evidences to suggest that the practice of bone surgery was existent among Greeks even in the prehistoric times, the only important and known book of Greek texts was written at various intervals between the fourth century B.C. and first century A.D. which is known to history by the name of the physician to whom it was ascribed, the Corpus Hippocrates. Some of these books, viz. On Fractures, On Articulations and On Surgery, are specially devoted to the orthopaedic branch of surgery. But these have reference to the infancy of orthopaedics which waited till the discovery of Roentgen rays recently after which it made great strides.

Types of bones

Before proceeding to discuss bone-injuries, it may be necessary to have an understanding of the types of bones found in the body, as Suśruta understood them. This will not only give an idea of Suśruta’s classification of bones, but it will be of help to understand the effects of various injuries of these tissues. Suśruta has divided all the bones of the body into five types:¹

एतानि पंचविधानि सम्बन्धम्। तथाः—कपालः कुचकः तरण बलत्य नलकं संज्ञानि।

1. Kapāla (कपाल), flat bones
2. Rucaka (रुचक), small cubical bones
3. Taruna (तरण), cartilages
4. Valaya (बलय), thin curved bones, without a medullary cavity
5. Nalaka (नलक), long bones, with medullary cavity

Further, describing these types in more detail, he says that the ‘flat bones’ include patella, hip, scapula, mandible, hard palate, temporal and the other bones of the skull. The ‘small cubical bones’ are represented by the teeth. The ‘cartilages’ are found in the nose, ear, throat (cricoid, etc.) and the ocular socket (tarsus plate). The ‘thin curved bones’ encircle the back,
sides and front of the thorax (ribs). The remaining bones of the body are included in the group of ‘long bones’.2

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Suśruta’s terminology</th>
<th>Modern equivalent term</th>
<th>Bones included</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Kapāla</td>
<td>Flat bones</td>
<td>Patella, hip, scapula, mandible, hard palate, temporal, other skull bones</td>
</tr>
<tr>
<td>2.</td>
<td>Rucaka</td>
<td>Small cubical bones</td>
<td>Teeth (carpels, etc.)</td>
</tr>
<tr>
<td>3.</td>
<td>Tarupa</td>
<td>Cartilages</td>
<td>Nose, ear, throat, eye-socket</td>
</tr>
<tr>
<td>4.</td>
<td>Valaya</td>
<td>Thin curved bones</td>
<td>Ribs</td>
</tr>
<tr>
<td>5.</td>
<td>Nalaika</td>
<td>Long bones</td>
<td>Other bones of body, e.g. femur, tibia, femur, humerus, etc.</td>
</tr>
</tbody>
</table>

Aetiological factors

Suśruta has regarded ‘trauma’ as the primary cause contributing to the fractures, the chief etiological factor being trauma, such as fall from height, blows, bone infections, wild animal bites, etc.3

These etiological factors have been described by Suśruta in view of the commonest everyday injuries resulting in different types of fractures. Most of the population in those times was living in the jungles as townships and cities had not been fully developed and these were only few and far apart from each other. As such, the population in those days more frequently faced encounters with wild animals, which resulted in various types of injuries and fractures. These fractures were obviously compound fractures and have been described in the Suśratasamhitā. However, due to changed living conditions in the modern age, these fractures are not mentioned in the modern books of surgery. This shows that Suśruta was a very keen observer and he could apply his knowledge in a systematic and methodical manner for practical purposes.

Effect of trauma on bones

Each of the above-mentioned bones sustain trauma in different ways. Suśruta has paid due attention to this fact and observed that all the bones do not show similar types of effect for a similar trauma. He has, therefore, classified these effects into different groups and correlated them with the types of bones involved. Thus, according to Suśruta, after a certain trauma, the cartilages bend; the long bones break; flat bones show multiple cracks (star-shaped) and the small bones get fragmented4 (Fig. 1).
This fact helps greatly in diagnosing a particular type of fracture at a particular site. Today we are able to examine an injured bone directly under radiological examination, but in the absence of this, Suśruta evolved this useful and most logical method of determining the type of fracture.

**Classification of bone injuries**

Broadly speaking, all skeletal injuries have been divided into two groups:

1. *Sauvanabhagna* (सुवनभन), open or compound fracture,
2. *Avranabhagna* (अवरनभन), simple or closed fracture.

This classification has been clearly mentioned by Suśruta and he has certainly referred to it while dealing with the management of these cases. However, the later authors, viz. Vijay Rakshita and Shrikantha Datta, while commenting on *Mādhava Nidānām*, have made a direct reference to it:5, 6

Suśruta is seen to have had a clear idea about the differences between a fracture and a dislocation. So, he has first classified the skeletal injuries into two broad groups, viz. (a) injuries of skeletal origin involving joints and (b)
skeletal injuries proper. The dislocations have further been subclassified into six varieties, and the fractures into 12 varieties:7

Classification of skeletal injuries:

_Sandhimukta_ (सन्धिमुक्त),

i.e. dislocations

1. _Utpişṭa_ (उत्पिष्ठ)
2. _Viśṭiṣṭa_ (विशिष्ठ)
3. _Vivartiṭa_ (विवर्तित)
4. _Avakṣiṣṭa_ (अवकषिष्ठ)
5. _Atikṣiṣṭa_ (अतिकष्ठ)
6. _Tiryaṃkṣiṣṭa_ (तिर्यंकष्ठ)

_kaṇḍabhagna_ (काण्डभग्न),

i.e. fractures

1. _Karkaṭaka_ (करकटक)
2. _Aśvakarna_ (अश्वकर्ण)
3. _Cūrṇīta_ (चूर्णित)
4. _Picciṭa_ (पिचित)
5. _Asthichallīta_ (अस्त्विचलित)
6. _Kāṇḍabhagna_ (काण्डभग्न)
7. _Majjāṇugata_ (मज्जाणुगत)
8. _Atipāṭita_ (अतिपातित)
9. _Vakra_ (वक्र)
10. _Chinna_ (छिन्न)
11. _Pāṭita_ (पातित)
12. _Sphūṭita_ (स्फूटित)

Their nearest modern synonyms are:

_Utpişṭa_ (उत्पिष्ठ), fracture dislocation (Fig. 2)
_Viśṭiṣṭa_ (विशिष्ठ), dislocation due to tearing of ligaments (Fig. 3)
Vivartita (विवर्तित), anterior or posterior dislocation (Fig. 4)
Avakṣipta (अवक्षित), downward displacement (Fig. 5)
Atikṣipta (अतिक्षित), marked displacement of articulating surfaces (Fig. 6)
Tiryakṣipta (तिर्यक्षित), oblique dislocation (Fig. 7)
This classification of dislocations has obviously been made according to the different directions of forces that have caused displacement of the articulating bones in corresponding directions. This is the most practical way of grouping these cases and, even today, no better method of classifying dislocations than this could be evolved. It may be noted here that this is a complete classification and nothing more could be added to it in spite of the tremendous advances made by modern surgery.

Similarly, fractures have been divided into 12 varieties according to the type of injury.

They with their nearest modern synonyms are:

1. Karkataka (करकटक), depressed fracture
2. Aswakarna (अस्वकर्ण), complete oblique fracture
3. Churnita (चूर्णित), comminuted fracture
4. Piccita (पिच्चित), fracture by compression
5. Asthichallita (अष्ठिचल्लित), subperiosteal avulsion
6. Kandabhagna (कांडाभग्न), complete spiral fracture
7. Majjanugata (मज्ञानुगत), impacted fracture
8. Atipatita (अतिपातित), complete compound fracture
9. Vakra (वक्र), green stick fracture
10. Chinna (चिन्न), incomplete fracture
11. Patita (पतित), comminuted fracture of flat bones
12. Sphuitta (स्फुट्तित), fissured fracture

It can be seen from this classification that Suśruta described these fractures in respect to the position of broken fragments. The very fact, that he was able to diagnose a particular variety without the help of Roentgen rays (which were not discovered in those days) only from the direction of force causing fracture and from the deformity at the site caused by muscular components, is suggestive of his keen clinical sense and the power of logical imagination. The important point to note, in this classification, is that it not only includes all the varieties of fractures known today, but it also carries some minute observations like periosteal avulsion and is therefore more complete and superior to the modern classification of fractures. In fact, Suśruta has viewed fractures as 'bone-injuries' in the true sense and not merely as the discontinuity of a bony surface. This speaks for his deep understanding and capacity of recognizing the facts without altering their originality.

Clinical features

Suśruta has described separately the signs and symptoms of dislocations and fractures. Besides the clinical features of each variety, he has enumerated
certain general points to decide at first sight whether a fracture or a dislocation has taken place (Figs. 8 and 9). These features are of primary importance and worth considering here.

Fig. 8. General clinical features of dislocations.

Fig. 9. General clinical features of fractures.

The features which suggest a dislocation are inability to extend, flex, move sideways or circumduct the limb; severe pain; and tenderness to touch. 5
Swelling or deformity which is also an essential feature of a dislocation has not been included by Suśruta amongst the general features. However, he has mentioned it while dealing with each type of dislocation individually. This is probably because the shape of deformity is different in different cases and is important in the diagnosis of a particular variety.

The clinical features of a fracture described by Suśruta are marked swelling; tenderness to touch or to move; presence of crepitus; loss of function; different types of pain; and inability to find comfort in any position: 

Swelling: स्वयम्भुवम् स्थन विवर्तन स्पर्शास्त्रिणुत्तमविवर्तीसिद्धगत्वाद 
तोग्धस्त्वं विविधवदना प्राप्तमावः स्वस्वस्वस्वाभु त शर्म लाभं इति 
समासिन काण्डभूतं लक्षणमुक्तम्।

So, one can obviously see that the general features of a bone-injury, described by Suśruta nearly 3,000 years ago, are just the same as are written in any standard modern surgical textbook. In other words, what Suśruta wrote several centuries ago, with meagre facilities of carrying clinical investigations, is as a principle so thorough and perfect, that it hardly had room to permit any alteration or improvement. It evidently shows the keen clinical sense of Suśruta and the height of development of Indian Surgery in that period.

Prognosis

The prognosis of a case of skeletal injury depends on several factors, the important ones of which are age of the patient, site of the fracture, the type of fracture, the status of bone, the status of the patient and seasonal variations.

Age

The age of the patient is a very important criterion to decide the prognosis of fractured bones. Suśruta has given due consideration to this factor. According to him, the middle age is regarded as the most suitable period for the healing of a fracture.

Childhood and old age, both have been regarded as the difficult periods by Suśruta. Old age decidedly has a bad prognosis because of the low vitality and less regenerative power. But how Suśruta found early age as showing a less response? According to modern theories, the younger the bones, the better is their capacity to regenerate. In practice also, we find that the young subjects have a quicker healing. How then Suśruta had an opposite view needs going
back to the Suśrutian Age of Surgery. We know that Suśruta practised surgery under the most meagre facilities where the anaesthetics and sedatives or even analgesics were unknown. In the circumstances, it must have been a problem to secure voluntary co-operation of young patients during treatment. This might have resulted in improper reduction or inefficient fixation leading thereby to malunion. So, this is one possibility why Suśruta regarded young age as showing a bad prognosis. But, if ideal reduction and immobilization are achieved in young age, too, Suśruta also agrees that the healing would be effected quickest of all the age-groups\textsuperscript{11} (Fig. 10).

![Diagram of fracture healing and age effect]

**Fig. 10. Effect of age on prognosis of fractures.**

He has clearly mentioned that in early age the healing of a fracture takes one month’s time whereas it takes about two months in middle age and three months in old-age subjects:\textsuperscript{12}

\begin{itemize}
  \item Prayam baris tavan bhram suksramadivesat
  \item Aparoayasya jatottas kalya cha shubhvardah
\end{itemize}

**Site of fracture**

The fracture of skull, resulting in a brain injury, or fracture or dislocation of spine, resulting in a section of the cord, are serious accidents as compared to an ordinary fracture showing difficult prognosis. This fact was very well brought out by Suśruta and its importance has been strongly emphasized by him.\textsuperscript{13}
It must be clearly borne in mind that Suśruta treated the patient as a whole and not the injury alone. Therefore, the prognosis described by him implies the survival of the patient and his ability of returning to the normal living apart from healing of the lesion of injury.

**Type of fracture**

The extent of bone injury has also been considered by Suśruta. Thus, there are certain types of fractures which involve damage to the bones beyond the possibility of repair, e.g. *curṇita, chinna, atiḥāṃśita* and *majjāṅugata*. These have been mentioned as difficult for treatment: 14

> तेषु चूणितविश्लेषणातिपतितमज्ञानायांतानि कृष्णाः आयामि ॥

**Status of bone proper**

The fractures of previously deformed or diseased bones or joints have also been regarded as incurable by Suśruta. 15

> आदितो वचन हर्जितमात्र सन्निष्ठविधि वा ॥

It should be understood that the deformities which already exist may be caused either congenitally or due to some acquired disease. Thus, the pathological fractures that occur as a result of weakening of bones, due to a pathological condition, also fall in this category and they are of bad prognosis. Similarly, the fractures, which have gone into malunion or non-union due to an improper apposition or inadequate immobilization or repeated traumatization, have been considered as beyond the hope of good repair. 16

> सम्यगविमलभानां हर्जितमात्र सन्निष्ठविधि ॥
> संविश्वांशिपिर यद्ग्रंथितमहितिया तथा कवितेव ॥

Thus, Suśruta realized that the neglected or improper treatment does permanent harm to a broken bone. Therefore, the first treatment must be essentially accurate and effective, failing which a malunion or non-union would result.

**Status of the patient**

The general condition of the patient is also an important factor which has a bearing on healing of the fractures. This point, too, has not been omitted by Suśruta. He has clearly mentioned that the old and emaciated persons and also those suffering from debilitating diseases like tuberculosis, leprosy and chronic asthma are subjects of difficult prognosis. 17

> क्षणुद्वारालात्तः क्षत्रीणां कुङ्कुमम् दानवतेषु शर्यं ते वेषित ॥

Evidently, these persons have poor vitality and low reservoir of calcium and other substances in the blood needed for bone repair.
Besides these factors, the affection of *doshas* and the seasonal variations also influence the healing of fractures. Suśruta regards winter as the best season as compared to summer and others. Similarly least involvement of *doshas* indicates better prognosis:¹⁸

...काले च विशिष्टातः।

In the end, Suśruta has referred to the nutritional status of the patient, his constitutional peculiarities, e.g. thyroparathyroid disorders producing irritability, etc., and the presence or absence of complications as the final factors that influence the curability of a case. In his opinion, if the patient is poorly nourished, has a *vatic* constitution (*prakṛti*) and the fracture is accompanied with complications, it is definitely a case which presents difficulties in management:¹⁹

अत्याधिकानांतरं ज्ञातो भागावतात्मकः।
उपर्वेदी जस्तः भयं कुल्लेले किंचित्।

*Complications of fractures*

The complications of a bone-injury may be (1) local or (2) systemic. The local complications have already been described by Suśruta as 'malunion' or 'non-union' resulting from improper reduction or ineffective fixation. The systemic complications such as fever, abdominal distention and cessation of passage of excreta like urine and faeces have been brought forward by Dallana while commenting on *Suśrutasaṃhitā*:²⁰

उपर्वेदीत उपद्रवं: ज्ञर: आद्यान मूत्र पुरीष संगावद:।

It may be noted here that these complications occur only in advanced cases after sepsis, resulting in septicaemia or toxaemia.

**Principles of Management**

The management of a case is always changing. What is accepted as the best type today is bound to be modified tomorrow. It is always devised to suit the needs of the day. Therefore, to expect that whatever means Suśruta adopted in the treatment of a case of skeletal injury nearly 3,000 years ago would be as effective even today is certainly not justifiable. The tremendous developments in all the fields of science and technology have changed the entire picture of the situation. However, there are certain principles behind every line of management, if correctly laid down, would universally remain unchanged whatever be the means that may be adopted to achieve them. The efficiency of Suśruta's skill regarding the management of a fracture case can be very well put to test on this basis.
Four principles of treatment

There are four principles which Suśruta has mentioned while treating a case of skeletal injury:21

आयाम्यफँ: पीड़नेकेञ्च संपेन्युवन्युवस्त्वु ॥
सत्ववीरोरे स्वास्थ्य चलान्य चलान्यपि । एतेऽस्तु स्वास्थ्यमापे: स्वायत्वमतिमान भिष्कु ॥

They are:

1. अङ्चन (अङ्खन), i.e. traction
2. Piḍana (पीडन), i.e. manipulation by local pressure
3. Samkepap (संकेप), i.e. apposition and stabilization
4. Bandhana (बन्धन), i.e. immobilization

These four objects are to be achieved in every type of fracture or dislocation by different methods. These methods may vary in an individual case under a particular situation but the objective remains the same (Fig. 11).

![Fig. 11. Four principles of treatment of skeletal injuries.](image)

Methods of reduction

Suśruta has further explained the process of reduction in different conditions. He has thus advised the elevation of a depressed fragment, to bring near and approximate the far displaced fragments and to pull apart the over-riding fragments.22

अवनामित युक्तेशु संयुक्तेशु ॥
अंच्छन्तिसंकेप्यां चिपिकित्वतेऽपि ॥

Obviously, these manipulations are aimed at one subject only, and that is to bring the broken fragments into an alignment. This shows how thorough was Suśruta’s understanding about a bone-injury.

Immobilization

Proper and stable immobilization is an important part in the successful management of a fracture. Suśruta has used several methods for this purpose. Of these methods, the use of splints has been widely discussed in his
Samhita. The barks and chips of several trees were selected to serve as splints. The important woods,23 which were commonly chosen and applied for this purpose, are madhuka (मधुक), udumbara (उदुम्बर), aswattha (अस्वत्थ), palasha (पलाश), kakubha (ककुभा), vansha (वंश), surja (सूर्या) and vata (वटा).

The availability of these materials is one factor in making their selection though their physical properties like usna (उष्ण), sita (सीत), mrdus (मदुस), ruksa (रुष), etc., were also considered according to the dosic involvement and the constitution. Thus the aim of splints, in Suśruta’s period, was not only to provide an effective immobilization but also to treat the injured site by the medicinal properties of these woods. There is a reason why barks were selected by Suśruta for splintage. The barks of trees have three important qualities which suit the requirements of a good splint. They are: (1) The limbs can exactly fit into the inner concave surface of the barks; (2) the outer surface of barks being rigid gives strength to the broken limb; and (3) the inner surface of barks being soft, acts as a cushion to the limb, thereby avoiding any pressure sore from tight splintage.

Ideal splintage

Ensuring of correct pressure in tying a splint has been greatly emphasized by Suśruta. He has warned that a loose splintage will not be able to achieve the desired immobilization; while, on the other hand, too tight a bandage might interfere with the vascular supply of the area resulting in oedema, pain and ultimately suppuration (Fig. 12). Therefore, a proper bandaging has been greatly emphasized:24

Warning against infection

Whatever be the management of a bone-injury, the primary duty of a surgeon is to see that no infection takes place at the injured site. He should make every possible effort to avoid contamination and infection. Once the bone-infection sets in, it is a difficult job to manage the case and the life of the patient becomes miserable. Suśruta had known this fact and, therefore, he has strongly recommended the adoption of measures that would avoid suppuration:25

1. tatraśīthividhānābhadbhūtaḥ samgajaya ratnaya
2. gadvīna deśāvanā śūkṣmaḥ pakaṇa eva ca
3. tasmān vaśyūrdvādāh iti śanasa tadbhiḥ

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Certain medicinal preparations

Suśruta has advocated certain medicinal compounds to be used at the fractured site. These compounds are used in the form of plasters or pastes. One of the important combination of drugs is a paste obtained by mixing the powders of maṇjiṣṭha, madhuyastī and rakta candana with pasted rice and 'hundred times washed ghṛta'.

It may be noted here that these medicines are to be applied immediately after the injury as a first-aid treatment. They soothe the part and minimize pain, local swelling and oedema. It may also be noted that they are used only in cases of closed fractures. The compound fractures are a contra-indication for these local applications as suggested by Suśruta:

Treatment of compound fractures

The treatment of compound fractures has been dealt with by Suśruta separately. In these cases, the skin-wound has to be treated first before immobilizing the fracture. For this purpose, the wound is dressed carefully.
with ghṛta and madhu and then the part is treated on the lines of fractures already mentioned:²⁸ (Fig. 13).

\[
\text{श्रवणस्य तु भग्नस्य व्रण सपिस्मृतरूपः।}
\text{प्रतिसायिक कषायस्य शोषे भग्नवदाचरत्।}
\]

**Fig. 13.** Treatment of compound fractures.

**Internal medication**

Suśruta has prescribed certain drugs to be used internally also. These are chiefly general tonics which provide liberal amounts of proteins, fats, calcium and mineralo-vitamins. This can be very well observed in the following popular preparation: ‘The patient with a fracture should take daily in the morning the milk of a primiparous cow processed with ghṛta, drugs of madhura group and lākṣā. It should be taken after it is cool.’²⁹

\[
\text{गृह्यो शैरं ससर्पेण मधुरीवशस्याचितम्।}
\text{वीत्तं वाह्यम् सृष्टं प्रात्मज्ञ: प्रियशः।}
\]

The milk of a primiparous cow is particularly rich in proteins. Besides this, there are additional quantities of fats and other substances added to this preparation which strengthen the bones.

By experimental trials of these drugs, it has been proved beyond doubt that these medicines have a definite role to play in the healing of fractures in various stages and various ages. The important point is to pay due regard to the dosa āyuh and bala of the patient.
Nutrition

Apart from the tonics, Suśruta has paid due attention to elevate the nutritional status of the diet of the patient to be taken in the routine. For this purpose he has advocated a liberal use of śāli (शालि) rice, meat preparations, milk, ghee, pulses and other dietetic elements as are supposed to enhance the process of Brjmhana (ब्रज्ञ), i.e. regeneration of different tissues:30

शालिमांवरस: कृषि सुपियूष: सतीज:।
वृट्ताण चार्यकान स्वादिष्य मन्नाय जानता॥

Some Highlights of Suśruta's Techniques

Besides these general measures, there are certain specific points mentioned by Suśruta in connection with the different bone-injuries which are of great interest and deserve consideration. When we go through these special milestones of management, there is no alternative left but to appreciate the surgical skill of the father of Indian Surgery. In fact, these must be regarded as the 'Glimpses of Suśrutian Surgery'.

Splintage by healthy limbs

The first of these glimpses is the management of fractured metacarpal bones. Suśruta has advised the joining of the injured palm with the palm of opposite side and to tie them together:31 (Fig. 14).

उजेति संह गुल्क्ता तलम्बनस्य वेहिनः।
बन्धीयादाम तेतल परिपेक यह कार्येत्॥

![Fig. 14. Splintage by healthy limbs.](image)

Now the use of a healthy limb as a splintage to support an injured limb came much later in the modern first-aid surgery, say, during the Second World War. But it was Suśruta who successfully employed this method in treating
a fractured limb several centuries before Christ. The credit, therefore, of devising such a ready natural splintage goes to him.

Rehabilitation

The importance of physiotherapy in a limb-injury was also appreciated by Suśruta. He has prescribed the exercises starting in small doses which may be gradually increased at any rate, and exercises should not be prescribed all at once in the beginning (Fig. 15). For this purpose, he has suggested that lighter objects may be held to begin with, e.g. a mud-ball, and then a heavier substance like a lump of rock-salt and finally still harder objects, e.g. stones.  

![Diagram](image)

**Fig. 15.** Gradual steps of rehabilitation.

This would avoid sudden jerking at the freshly healed lesion and would permit a better union by improving circulation.

Special devices (fracture-bed)

The next interesting point in Suśruta's technique of dealing with fractures is his method of immobilization of an injured lower limb. He is seen to have treated fractures of lower limbs or of pelvis by making the patient lie down on a wooden cot and by immobilizing the part with the help of 'five nails'
to be fixed on the sides of desired joints according to the site of injury in order to avoid any movement of the limb. The purpose of nails is to fix

\[\text{अब जड़ोस्थरनानां कपाटायन हिताम्} \]
\[\text{कड़िकाकर्तनाय च पञ्च काया विज्ञान} \]

**Fig. 16. Fracture-bed for fractures of lower limb.**

the part, one joint above and one joint below the site of injury, each joint being held by two nails. The remaining fifth nail has to be fixed at the sole, in every case, to stop the downward and side-to-side movements.

\[\text{यथा न चलन तत्प्रथ स्थित्व क्रियते तथा} \]
\[\text{सन्न्यासवतो दौ दौ तले चैकक फोलक} \]

This is something specific in Suśruta’s technique. It may not be as effective today since there are better types of modified splints available to serve different purposes; yet, it is undoubtedly the simplest method of achieving an effective immobilization of the lower limbs.

**Treatment of protruding bone fragments**

It is possible in a major accident that the broken bony fragment may protrude in a compound fracture. For such cases, Suśruta has advised the removal of the protruding bone by excision and the treatment of the part on the lines of a ‘compound fracture’ as already stated.
Fig. 17. Treatment of protruding bone fragment.

However, it should be remembered that an exposed bone should either be covered immediately with soft tissues or else, in a case where it is not possible, the bone should be excised; for an exposed bone is very prone to undergo necrosis.

**Treatment of malunited fractures**

Suṣruta has specified the treatment of fractures which have gone to malunion due to improper management. In these cases, he has advised the production of re-fracture of the malunited bone and the resetting of it cautiously:

\[
\text{काण्डभन्ये प्रक्ष्ये तु विस्मयनसंहिते।}
\]
\[
\text{आपोष्य समवेद्मग्न ततो भन्तवगदररेतु।}
\]

It has then to be treated on the lines of a fresh fracture (Fig. 18).

**Treatment of fractured spine**

The spinal injuries were also treated by Suṣruta effectively. For these cases, he has advised complete rest, being immobilized in a special (hard) fracture-bed with the help of nails described already:

\[
\text{शोषां वा जूतजवं वा वक्ष्यास्कपंस्तथा।}
\]
\[
\text{भन्तसन्य विमोक्षेषु विचिद्वेषं समाचरेतु।}
\]
However, he has also suggested the treatment of these cases with the help of enemas and urethral douches:\textsuperscript{38}

\textit{अर्थशुद्धिः यथावच विशेषतः तत्परत्मा तु भागिनम्।}
\textit{ततः स्तःसिद्धेति तन्ययो वत्तितिः: समुपस्रवेदः।}

A case of spinal injury is likely to develop retention of urine and faeces. So, enemas and douches are the necessary requirements in these cases in order to ensure proper evacuation.

\textit{Treatment of cervical injuries}

The fractures and dislocations of cervical spine are seen to have been treated by \textit{Suśruta} by providing traction from pulling the head upwards and correcting the deformity:\textsuperscript{39}

\textit{प्रीवायां तु विवृतायां विविंश्चतायामयोऽमि।}
\textit{अवस्थायं हुनवतः प्रमृत्तयामयोऽभिः।}
\textit{ततः कुष्टाय सम्म वस्त्रः वस्त्रपट्टेः वेष्टे।}
\textit{उत्तमां शास्ययेन उपरामानेतः।}

An important point in this connection is that he has further advised the immobilization of the neck with the help of suitable splints and then to keep the patient completely in bed-rest on his back for one week without fail.

\textit{Treatment of fractured clavicle}

It has been advised to reduce the fracture of clavicle after fomentation with the help of a wooden cylinder (\textit{musala}) and then to bandage it tightly:\textsuperscript{40}

\textit{समुष्कयत्वं वाकं मूर्तेन तु।}
\textit{तथापि मेति पीतवेष्टः वज्नियादंगांतः सं।}

The site for the application of the cylinder is probably at the back over which the two scapulae are tied tightly so that the clavicle is reduced and, at the same time, immobilized.
Treatment of injured tooth

According to Suśruta, even the bleeding and loose teeth (but unbroken) of a young man, after injury, should be compressed and fixed and allowed to heal:

असमांतव्यभित्ति दृक्कर्त्य सरक्तानुपि पीड़ेयत्।
तरणस्य मन्दव्यस्य शीतरात्लेयेऽद्विः॥
सिक्कवाद्वृद्धित्वा शीते सत्यानीयैऽथाचरेत्॥
उत्कलस्य च नालेन कीर्पाण्य विपीयते॥
जीर्णस्य तु मन्दव्यस्य वर्जयेश्वरचति ब्रजान्॥

During this period the patient is not permitted his normal meals. He is only allowed to suck milk with the help of a straw or a lotus stem. However, the loose teeth, in an old man, should be extracted.

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Fig. 19. Clinical features of ideally united fractures.

In the end of the chapter, Suśruta drafts certain criteria of ideally united fracture and gives in clear terms what a surgeon is to expect in a case of ideally healed fracture (Fig. 19):

1. Absence of gap between the broken fragments.
2. Absence of shortening.
3. Absence of deformity.
4. Return of painless and easy movements.
When the surgeon satisfies himself about these four features clinically, he should declare that the injury has healed ideally.\footnote{\textit{Suśruta on the Fundamentals of Orthopaedic Surgery}}

\begin{flushright}
भग्नं सन्ति:मन्दमहीनास्वतः ज्ञाननुदारयम्।
सुखेष्ठाप्नारं च संहितं सम्यगादिशैतः॥
\end{flushright}

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27. \textit{Ibid.}, Cī, III, 47.
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Reference is also made of the following text: