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Oral Health Status in Indian Children with Cerebral Palsy - A Pilot Study

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Abstract

Cerebral palsy is a major severe childhood disability and its prevalence is increasing, particularly among premature low birth weight newborns. Less attention is paid to dental health in these children. This study aimed to investigate various dental problems such as dental caries, plaque index, malocclusion and drooling in a group of 53 Indian cerebral palsy children. The results were compared with a control group of 53 age and sex matched normal children. Non-parametric statistical tests were used, with the level of significance set at $p<0.05$. The results showed a significant difference between cases and controls for caries. No significant difference was noted for malocclusion. One of the significant finding was that the children affected with drooling were not affected with caries teeth. Conclusion- Good oral hygiene, accompanied by early and regular dental examination and treatment will enhance good dental health in cerebral palsy children.

Introduction

Cerebral palsy is defined as a non- progressive disorder that manifests as abnormality of motion and posture and results from a central nervous system injury sustained in the early period of brain development, usually defined as first 3-5 years of life.[1] Advances in perinatology have led to increasing survival of preterms and a change in the distribution of the clinical types of cerebral palsy.[2, 3] A number of studies have been done for the clinical spectrum or associated risk factors in cerebral palsy children but very less attention is paid to the dental health in these children. The cerebral palsied children face a number of dental problems like other children. These problems include caries teeth, periodontitis, malocclusion, bruxism and tooth decay. The difficulty in swallowing in these patients leads to drooling. Inability to perform oral hygiene procedures contributes to the increased incidence of dental diseases in these patients. Furthermore, seizures are common in cerebral palsy patients and anti-epileptic drugs especially phenytoin sodium can cause gingival overgrowth which complicates oral hygiene procedures, making it more difficult to control dental plaque.

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Aims and Objectives

The aims and objectives of the present study are to evaluate the oral health status in Indian children with cerebral palsy using WHO criteria; to evaluate curative and preventive methods to fight dental caries; and to know the role of excessive salivation on oral health status in cerebral palsy children.

Material and Methods

53 cerebral palsy children attending the OPD of PMR, AIIMS were included in the study. After clinical assessment, a clinical psychologist did IQ assessment. Oral examination was done by a Pedodontist using DMFT

criteria as per WHO Oral Health Assessment Form (1997). Oral Hygiene Plaque Index (modified Loe and Silness) was used for evaluating plaques. Assessment for malocclusion was done clinically. Excessive salivation was also recorded. The patients were compared with equal number of age and sex matched controls attending the OPD of Dental Surgery.

Results

The maximum cases were in the age group of 6-8 years. Quadriplegics and diplegics constituted maximum number of cases (Table 1). On IQ assessment, it was seen that children with mild mental retardation were maximum followed by moderate mental retardation (Table 2). Significant difference was noted between cases and controls for caries (Table 3 and Table 4, Fig 1, 2 and 3). In cases average DMFT was 2.22 and controls it was 1.52. (D stand for decayed tooth, M for missing, F for filled. DMFT stand for permanent tooth, dmft stands for primary tooth or milk tooth). There were 11 patients with malocclusion (Table-5, Fig-4), highest with bimaxillary prognathism. For plaque index and malocclusion no significant difference was observed between cases and controls. Drooling was observed in 13 children (Fig 5). An important finding was that none of these children were affected with caries teeth. The treatment required by most of the children was restoration of the teeth. Other treatment advised was plaque control programme, brushing techniques, modifications of tooth brushes (fruit or ball shaped handles using foam or POP), anti microbial agents, use of tooth paste containing fluoride, caries filling, diet control along with spasiticity management and proper postural advice.

Table-1: Topographical distribution of cases.

Type of cases	*Number of cases*
Quadriplegic	20
Diplegic	26
Hemiplegic	3
Monoplegic	1
Athetoid	3

Table-2: Distribution of cases on IQ assessment.

Type of cases	*Number of cases*
Average	7
Borderline	4
Mild	15
Moderate	13
Severe	9
Profound	5

Table: 3: Results of primary dentition deft: (cerebral palsy n=113, Controls n=68):

Variable	d	e	f	t
Cases	98	15	2	0
Controls	59	7	0	0

Table-4: Results of permanent dentition DMFT (cerebral palsy n=5, Controls n=13):

Variable	D	E	F
Cases	5	0	0
Controls	13	0	0

Total DMFT+deft: Cerebral palsy-118, Controls- 81
Average DMFT +deft: CP-2.22, Control – 1.52($p<0.01$)

Table-5: Distribution of cases with malocclusion

Type	*Cases*	*Controls*
Crowding	3	2
Maxillary prognathism	2	2
Bimaxillary prognathism	4	0
Malocclusion-class II	2	4
Normal occlusion	42	44

Table-6: Oral hygiene scores

	Cerebral palsy	*Controls*
Poor	0	0
Moderate	34	21
Good	19	34

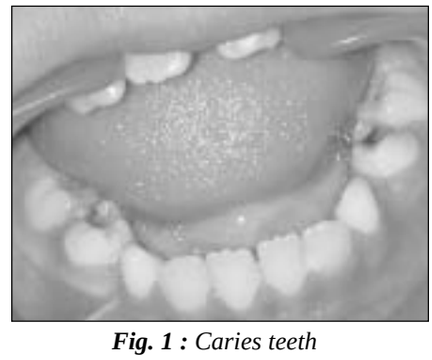

Fig. 1 : *Caries teeth*

Fig. 2 : *Rampant dental caries with missing teeth*

Fig. 3 : *Nursing bottle caries*

Fig. 4 : *Malocclusion*

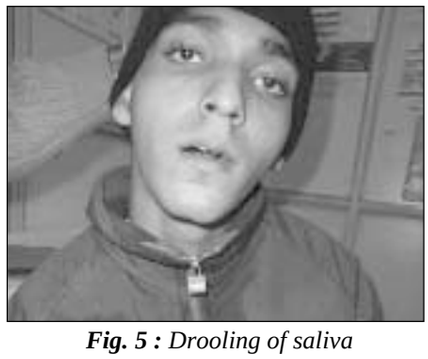

Fig. 5 : *Drooling of saliva*

Discussion

A number of studies related to dental disease in cerebral palsy have been done in the west but till now we have not come across any study that has been done to evaluate dental problems in cerebral palsy children in India. The purpose of this study was to assess dental problems in Indian children with cerebral palsy. We found that there was significant difference between cases and controls for caries. In contrast, Pope JE et al found a similar incidence of caries between cerebral palsy children and controls, but the study children had more extracted and unrestored teeth, and fewer and poorer quality restorations than control children.[4] Bhavsar JP et al in a study for dental caries and oral hygiene amongst 12-14 years old handicapped children of Bombay, found that prevalence and severity of dental caries was highest in cerebral palsy group and lowest in the blind group.[5] Malocclusion is the attrition of teeth through grinding. For malocclusion no significant difference was noted. The misalignment of teeth in cerebral palsy may be due to abnormal alignment of the tongue, lips and cheeks. In a study of Greek children with disabilities the highest rate of malocclusion was observed in children with cerebral palsy.[6] Another study of oral conditions on cerebral palsy children showed a significantly higher DMFS index for cerebral palsy children with permanent dentition when compared to normal children, also a significantly higher plaque index and higher percentage of malocclusion was observed.[7] Drooling is another common problem in these children. It is related to abnormality with swallowing and difficulties in moving saliva to the back of the throat. This is due to the misalignment of teeth and the lack of control of the muscles within the mouth. It can also be made worse by a lack of head control, poor posture, lack of sensation around the mouth, impaired concentration or an obstruction within the nasal cavity. A study done by Tahmassebi et al showed that drooling in cerebral palsy children is not due to hypersalivation but rather due to swallowing defect.[8] Management includes drugs like transdermal scopolamine to dry up salivary secretions. Latest development in the management of drooling is USG guided intraglandular injection of botulinum toxin type A into the salivary glands.[9] Surgery can be done in severe cases of drooling by parotid duct ligation and submandibular duct diversion.[10] But it has been shown that caries prevalence increases after surgery.[11]

Education of patients, parents and health care providers is still a big challenge. Various modifications of toothbrush handles, oral anti-microbial agents and topical and systemic fluorides can enhance home care results. The active participation of parent and patient will go a long way towards achieving and maintaining oral health.

Conclusion

Most dental diseases can be prevented. Successful application of sound preventive measures and regular follow up tends to lessen time of treatment for each patient. Good oral hygiene, accompanied by early and regular dental examination and treatment will enhance good dental health in cerebral palsy children.

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Study of Surface Electromyographic Changes in Paraspinal Muscles Following Spinal Muscle Strengthening Exercises in Non-Specific Chronic Low Back Pain Patients

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Abstract

Chronic low back pain (CLBP) is one of the most common cause of discomfort and demoralizing health problems disabling mostly individuals with age less than 45 years of age. Dysfunction of the erector spinae is one of the most common causes of CLBP. The aim and objective was to study the changes in surface electromyographic (SEMG) signals in paraspinal muscles (erector spinae) of patients with non-specific chronic low back pain before and after undergoing exercise therapy. TECA pre-jelled, disposable, self-adhesive 1 cm silver chloride bar surface electrode were attached to the skin overlying the erector spinae at T7, L2-3 and L4 vertebrae unilaterally on right side with a reference electrode over the right deltoid and SEMG signals were recorded in synergy mobile multimedia EMG and the turns and amplitude of the interference pattern were analyzed before and after undergoing strengthening exercise program. Pain status of the patients was also analyzed by using visual analogue scale and Quebec back pain disability scale (QBPDS).

Sixty patients with CLBP (44 male and 16 female, mean age 38.6+ 6.8) were studied. There were significant changes in the parameters i.e. amplitude and density, of the IP at L2-3, L4 and amplitude of T7 except in density of T7 after therapy. Change in amplitude and density (Increase in amplitude and respective reduction in density) was consistent with the significant reduction of pain shown by change in VAS and significant reduction in disability shown by QBPDS.

Conclusions of the study were (1) erector spinae muscle dysfunction could be one of the most predominant factors in developing nonspecific chronic low back pain. (2) Analysis of interference pattern by using noninvasive SEMG technique could be a useful noninvasive instrument to measure the increase in strength of muscles after exercise. (3) Best exercise in non-specific CLBP might be by using both flexion and extension program.

Introduction

Low back pain (LBP) is one of the most frequent musculoskeletal problem and is a major source of discomfort and demoralizing health problem causing disability in individuals less than 45 years of age, who are in economically most productive age group, giving indirect impact on the national economy.[1,2] Although rarely threatens life, it is extremely disabling, more so in ambulatory patients.[3] Pain is a very subjective personal experience and the presentation of LBP differs from individual to individual and it includes pain, ache, stiffness and fatigue localized in the lower back[4].

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Epidemiological studies from all over the world has demonstrated the enormous societal impact of the low back disorders that caused worker absenteeism.[5,6,7,8,9] At least 75% of all people would at some time of life, have LBP and about 30% of adult population has a back problem on any given date.[10] The cause of LBP is difficult to discern and specific lesion is found in only 10 to 20 percent of persons with acute LBP.[11] Therefore, the majority of patients presenting with LBP can be classified as non-specific.

Complimentary studies has documented compromised lumbar muscle function or weaker trunk muscle strength in patients with chronic low back pain (CLBP) than the normal population, [12,13,14,15,16] There are about 500 hypotheses of origin of CLBP but one of the most significant causes is dysfunction of erector spinae.[2] Electromyography (EMG) has been in use for long to study the electrophysiological properties of nerves and muscles. Since the introduction of Willison's[17] quantitative method of turns and amplitude analysis of interference pattern, many workers had investigated, modified and extended it.[18,19] Many different researchers had used the interference pattern analysis of EMG and an excellent review by Fuglsang-Frederiksen Andres[20] summarized these studies. These methods used the concentric needle electrodes to obtain the EMG data from the muscles tested.

Surface electromyography (SEMG) has been suggested as an objective, noninvasive method of testing and analyzing the degree of muscular activity and function.[21,22,23,24]

Materials and Methods

60 patients (44 male and 16 female) in the age group 30 to 60 years who had been suffering from non-specific low back pain for at least 6 months, who were symptomatic at that time of presentation and who were able to understand and perform the prescribed exercises independently were included in the study.

Using visual analogue (VAS) scale of 0 to 10 cm, and Quebec back pain disability scale (QBPDS), the intensity of pain was assessed initially. Patients were explained about the procedure. Temperature of room was maintained to be comfortably warm. Patients were put in prone position on an examination couch with lower body from the superior border of the iliac crest downwards strapped to the couch (Fig.1). Skin was properly prepared and TECA pre-jelled, disposable, self-adhesive 1 cm silver chloride bar surface electrode were applied unilaterally at three different levels on the right side 3-4 cm away from the midline, one at a time. First was applied at the level of T7 spine, second, between L2 and L3 spine and third, at the level of L4 spine with a reference electrode over right deltoid and ground electrode on left arm. Patients were asked to touch their ears with the hands, elbows out to the sides and level with the trunk and the hands in neutral position. Then they were asked to maintain the unsupported upper part of the body in a horizontal position for two seconds. Patients were made to understand what exactly would be doing by practicing the above-mentioned position 2/3 times before recording the signals and were also constrained to produce the same amount of mechanical (effort) output at each test to eliminate the effect of motivation or producing inconsistent maximal effort.

SEMG signals were recorded from the respective sites while patient was maintaining the horizontal position for 2 sec. Three recordings were taken from each site with a rest period of 2 minutes between each recording in order to avoid the effect of fatigue, and the signals were saved in the synergy mobile for later analysis and comparison.

The filter setting used was 3Hz for the high pass filter and 10 kHz for the low pass filter. The sweep setting was 100 msec per division and sensitivity was 500µV per division.

Data collection

The signals were digitized in a 16-bit AD converter. A turn was indicated when the amplitude of the previous turn and the next peak was more than 100 µV. The amplitude was measured between two accepted turns. Density i.e. the turns per unit time, and amplitude were analyzed on line. Each parameter was taken three times from each of the respective sites and their arithmetic mean was taken for comparison with the signal readings after therapy.

Intervention:
Exercise and back care in ADL

Back strengthening exercises were demonstrated to the patients to do at home. They were asked to do each set of exercise 15 repetitions twice daily for at least 5 days in a week with back care measures. They were emphasized the importance of doing regular exercise as advised and a diagram showing all the exercises and back care measures were provided to each patient. Non-steroidal anti-inflammatory medication, diclofenac sodium 50 mg (Voveran) was given when there was acute exacerbation of pain that could dispel or hindered the patient from doing exercises, for a short period of time. After initial assessment patients were followed up for every 2 wks i.e. on second, fourth and sixth weeks on OPD basis and the VAS (visual analog scale) and QBPDS (Quebec back pain disability score) were recorded on each visit.

Table 1: Descriptive statistics of changes in the parameters of SEMG (Surface electromyography), VAS score and QBPDS score before and after therapy

SEMG Parameters	Before therapy				After therapy				p-Value n=60
	Minimum	Maximum	Mean	S.D.	Minimum	Maximum	Mean	S.D.	
Density T7	44.0	145.0	84.9	17.7	51.0	132.0	82.3	18.6	.236
Amplitude-T7	327.2	1158	636.6	202.0	314.3	1278	700	224.5	.006
Density L2	73.3	160.0	104.2	19.6	59.9	154.0	97.9	19.4	.001
Amplitude-L2	345.6	1006	600.2	187.3	402.0	1392	678.8	237.7	.000
Density L4	65.0	145.0	108.9	16.9	60.0	158.3	97.8	18.8	.000
Amplitude-L4	330.8	1239	631.4	214.1	374.7	1363	738.3	267.5	.000
VAS	2	9	5.08	1.3	0	7	2.8	1.8	.000
QBPDS	7.4	50.6	27.9	11.3	2	44.2	18.6	11.4	.000

Statistics

All SEMG (surface electromyography) parameters, VAS score, QBPDS score descriptive statistics were worked out in terms of mean, standard deviation, minimum and maximum value. To see the association between qualitative variables Chi-square test/ Fisher's exact test was carried out. To compare the changes in levels of various SEMG quantitative variables (density T7, amplitude T7, density L2, amplitude L2, density L4, amplitude L4) after therapy in comparison to pre-therapy, paired t-test was used. Changes in these variables including those in VAS and QBPDS were used to work out correlation coefficient between them. Differential comparison of changes in each of the SEMG variables including VAS score and QBPDS score was carried out in relation to sex, age, height and BMI using appropriate statistical methodologies like unpaired t-test/ Wilcoxon rank sum test or one way analysis of variance/ Cruskal Walli's test etc. In case of significant results under analysis of variance/ Cruskal Walli's test, multiple comparison tests were carried out to identify the pairs of groups having significantly different results. To compare the use of analgesics before and after intervention, Mc Nemar test was used. The result was considered significant at 5% level of significance.

Results

The change in interference pattern (increased in amplitude and reduction in density) recorded by SEMG technique from the paraspinal muscles after therapy was significant and this could objectively demonstrate the increase in strength of the muscle and clinical improvement of symptoms in nonspecific CLBP. The correlation between this change and change in score of VAS and QBPDS and reduction in the requirement of analgesic medication at the end of the study showed the overall improvement and utility of SEMG in the assessment of non-specific CLBP after exercise and rehabilitation.

Discussion

Low back pain is still a major health problem not only in developed countries but also in developing countries like India. There were cases of back pain associated with organic diseases, which were excluded from the study, many of the cases were without any demonstrable or detectable cause thereby categorizing them as nonspecific after thorough examination and investigation, and almost all of them were suffering chronically for a long time.

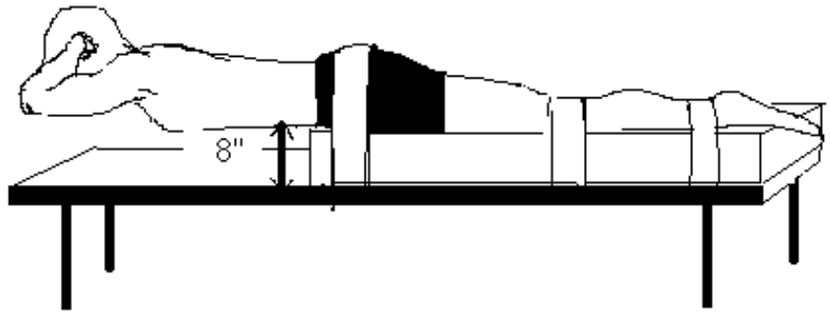

Fig. 1 Patients lower body strapped and maintaining a horizontal position

The simple low back pain also known as nonspecific low back pain or mechanical LBP is of musculoskeletal origin in which symptoms vary with physical activity. There is little correlation between the anatomic identification of pain "generators", clinical syndromes or actual pathology.[25] Muscle weakness is one of the most important causes of chronic low back pain[12,13,14,15,16] with erector spinae muscle being the most concerned one. Erector spinae muscle contracts eccentrically in flexion activities as decelerating muscle. When done excessively and repeatedly, fatigue results. With the weakened muscle, the other structures of the functional unit of spine the disc especially are exposed to excessive and inappropriate stress.

The duration and amplitude of the MUP (motor unit potential) reflex the number and density of muscle fibers comprising the motor unit. At maximum contraction, many motor units begin to fire rapidly. The simultaneous activation of these different motor units precludes recognition of individual motor unit potentials. Thus it produces a dense pattern of multiple superimposed potentials known as interference pattern (IP). A number of factors determine the spike density and average amplitude of the summated response. These include:

- Descending inputs from the cortex
- Number of motor neurons capable of discharging
- Firing frequency of each motor unit
- Waveform of individual motor potentials and
- Probability of phase cancellation.

Despite such complexity, its (IP) analysis provides a simple quantitative means of evaluating the relationship between the number of firing units and the muscle force exerted with maximal effort.[26] It mainly gives information about the number and size of MUPs at higher force level.

Different methods have been established to analyze the IP[17,19,27] such as integrated EMG, frequency spectrum, turns and amplitude (Willison) technique, experts quantitative IP (Equip) analysis. The essential features in all these are use of needle electrodes. Surface EMG has been suggested to be a useful method for diagnosis and assessment.[2,22,28,29,30,31,32,33] For global assessment of interference pattern mean amplitude and mean density is used.[34] Collecting myoelectric signals using surface electrodes is not technically difficult but has been poorly investigated. On the other hand SEMG is not without drawbacks. Signal degradation due to subcutaneous fat is an important theoretical point[31] and some parameters like insertional activities cannot be studied. Also spatial summation resulting from the gap between electrode and signal source leads to phase interference and cancellation at the electrode and consequent lowering of the frequency content.[35]

In this study we used SEMG technique and studied the IP in CLBP patients recording the mean density and mean amplitude and compared the result before and after giving therapy for LBP (exercises and back care). To study IP, the patient has to perform maximal contraction of the muscle; In the original Willison's technique,[17] he used a standard 5 kg, without regard to the force exerted during a maximum voluntary effort. Fuglsang-Frederiksen A and Manson[36] found the best diagnostic yield by using a relative force 30% of maximum. Arnall FA and Koumantakis GA[37] suggested that at 50% maximal voluntary contraction all the parameters were acceptably reliable in functional testing of the paraspinal muscles; here we are comparing the myoelectric signals collected while the patient performs an isometric contraction of the paraspinal muscles while maintaining the unsupported part of upper body in horizontal position, before and after therapeutic exercises. All the patients were constrained to produce the same amount of mechanical effort at each test to eliminate effects of motivation or inconsistent maximal effort as far as possible.

On paired t test there were significant changes in the parameters i.e. amplitude and density, of the IP at L2-3 and L4 (p=0.001 and 0.000) and amplitude of T7 (p=0.006) except in density of T7 (p= 0.236) after therapy (Table 1). Change in amplitude and density (Increase in amplitude and respective reduction in density) was consistent with the significant reduction of pain shown by change in VAS (p=. 000) and significant reduction in disability shown by QBPDS (p=0.000). Regarding use

of analgesics during the study period, there was significant reduction in the use of analgesics at the end of the study, 80% of the patients had stopped or needed rarely. But 20% of the patients still needed the medication.

Density indicates the number of motor units and their frequency of recruitment. High frequency or rapid recruitment i.e. increase in mean density is typical of weak muscles and less dense pattern may occur with a loss of motor unit, poor effort, UMN lesion or a strong muscle.[34] When the muscles are weak many motor units are recruited on contraction to perform certain amount of work (in this study the work done was to maintain the unsupported upper part of the body in the horizontal position) and it was shown by the increased density in the SEMG signals. When muscles become stronger, less motor units were recruited to do the same amount of work and this was evidenced by the reduction in density of recruitment pattern.

Exercise increases the strength of muscles is a well known fact.[38,39,40] In this study after exercise, prescribing both spinal flexor muscle strengthening and extension exercises, giving more emphasis on extension exercises therapy there was significant reduction in density of the IP. This could probably be correlated with the increase in the strength of the muscle

On the other hand, amplitude reflexes the density of muscle fibers within the MU territory, their diameter, and synchrony of their contraction[34]. Our finding in the present study demonstrated that there was significant changes in the amplitudes i.e. increased amplitude at different levels of erector spinae muscle ($p = 0.000$). Amplitude tends to increase linearly with the force.[36] This could be correlated that in a patient with CLBP there was drop in the number of muscle fibers, smaller muscle fibers, lower synchronicity (Przemyslaw L)[2] in contraction which after exercise and rehabilitation program there was increase in the size of muscle fibers and there was higher synchronicity of the muscle fibers in contraction i.e. while doing the same amount of work done before therapy.

The probable explanation of some difference in results (Table: 1) in different levels viz. T7, L2-3 and L4 could be because of the difference in the distribution of two main sorts of fibers slow twitch type I fibers and fast twitch type fibers in these parts of the erector spinae.[41]

The diameter of slow twitch fiber is larger than that of fast twitch fibers. In the lumbar region, relative area of the muscle occupied by type I fiber is significantly greater than that in the thoracic region. The predominant activity of the muscle is generated by the slow twitch fibers in such kind of muscles (Przemyslaw L)[2] In concurrence to this Yettram AL et al[42] also demonstrated that the paraspinal muscles in the lower lumbar region contributed more force than muscles located at higher lumbar level while performing an activity.

There was still considerable debate in the literature regarding the relationship between pain, muscular function and EMG results,[43] in our study we found that improvement in the muscle function which was directly shown by the objective changes in the SEMG parameters has a very good linear relationship with the reduction of pain and disability shown by reduction in the scores of VAS and QBPDS. Besides, this also supported the previous investigations suggesting that SEMG is useful diagnostic and assessment tool in the assessment of CLBP.

Conclusions

From the above study it can be concluded that:

1. Erector spinae muscle weakness could be one of the most predominant factor in developing nonspecific chronic low back pain, or turning the acute low back pain to chronicity.
2. Surface electromyography (SEMG) could be a very useful technique for the assessment of treatment response in nonspecific chronic low back pain patients.
3. The analysis of interference pattern by using SEMG technique gives useful information about the changes in the muscle after undergoing strengthening exercise of the muscle. This could probably be reproducible if we control the force exerted and duration of contraction during which the signals were recorded. But it would need a multivariate discriminant statistical analysis for a more significant interpretation.
4. The actual association between pain, muscle strength/weakness and disability and their relation with the SEMG parameters could be established.
5. The best exercise for nonspecific CLBP might be by using both spinal flexion and extension exercises. But the exercise should be monitored in the initial period of therapy for an optimum level of performance without pain and gradually increasing the degree/intensity to a prescribed level. The basis for exercise regimen should be to strengthen and condition the weak muscles thereby stabilizing the spine.
6. SEMG technique is non-invasive, without the risk of infectious complications, technically easy to apply, more patient compliance, rapid assessment, better option for the application or assessment of paediatric patients who generally are reluctant to needles and definitely for patients with bleeding

disorders. With appropriate signal processing this may provide very useful information not only for assessing but also for diagnostic purposes of many neurological and musculoskeletal disorders.

Recommendations

1. Further study with a larger sample size of non-specific CLBP, undergoing muscle strengthening or rehabilitation program to see the difference in the SEMG signal changes among different groups of subjects following therapy is needed.
2. Comparative study may be done between EMG signal changes where changes in data collected by needle electrodes is compared with changes in data collected by surface electrodes
3. Further case control study with control patients of non-specific CLBP who are under treatment with modalities other than muscle strengthening or rehabilitation program and cases who are undergoing strengthening exercise and rehabilitation program, and blinded testing of paraspinal SEMG
4. Technological advances, which are available for automatic analysis of interference pattern with on-line results and statistical values, such as EMG Lab computer system, could be combined with more clinical research on the applicability of surface EMG.

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Management of Crouch in Cerebral Palsy Diplegia

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Abstract

Crouch gait or posture is one of the most resistant conditions to treat in cerebral palsy with spastic diplegia. Twenty nine such patients (19 males, 10 females); aged between 3 to 16 years (mean 8.9 years) were treated at the Department of Physical Medicine & Rehabilitation, Regional Institute of Medical Sciences, Imphal from January 1992 to December 2003 by partial transfer of distal hamstrings to correct crouch gait. Semitendinosus and biceps femoris tendons were transferred to lower femoral condyles by fixing to tendinous origins of corresponding gastrocnemi. Semi-membranosus tendon was not transferred; but lengthened and it was left to serve as knee flexor. Results were assessed at 6 weeks, 3 months, 12 months after operation based on reduction of popliteal angle, increase of hip extensor power, improvement in balance and gait. Accordingly, 6 cases were graded as excellent; 16 as good; 2 as fair and there was no patient in poor grade. Genu-recurvatum occurred in 2 cases. Patients were followed up for a period ranging from 1 to 10 years (mean 5.5 years). This method of partial transfer of distal hamstrings is effective in relieving crouch gait in spastic diplegic cerebral palsy.

Key Words: **Cerebral palsy, Crouch gait, Spastic, Diplegia, Hamstrings transfer, Hamstrings lengthening**

Introduction

Crouch gait/ posture is one of the most resistant conditions to treat in cerebral palsy with spastic diplegia. Conservative treatments like stretching of spastic knee flexors, strengthening of knee and hip extensors, fitting of orthosis fail to address this problem in majority of cases. Most popular method of treatment of crouch gait is lengthening of hamstrings which reduces knee flexion – the most important component of crouch complex directly. Injection of botulinum toxin in hamstrings to weaken it is also another method of treatment. More rational approach in treating crouch gait is to transfer distal hamstrings to distal femur in which the deforming force is utilized for improving hip extension. The earliest reported operation of this type is Egger's operation[1]. In this operation, the problem of pelvic tilt is solved by improving hip extension. However, genu-recurvatum is the common complication after this procedure. Evans[2], Ray and Ehrlich[3] reported modifications to Egger's technique to avoid this complication. In this study we transfer semi-tendinosus and biceps femoris to femoral condyles to function as hip extensor and retain semi-membranosus as knee flexor to prevent genu-recurvatum. Semi-membranosus is appropriately lengthened to correct knee flexion deformity.

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Objective

The objective of this was to test the effectiveness of our method of partial transfer of distal hamstrings combined with appropriate lengthening of remaining hamstrings in correcting crouch gait in CP diplegic; and of minimizing the usual complications like pelvic tilt, genu-recurvatum associated with transfer of hamstrings reported earlier.

Materials and Methods

Twenty nine CP diplegic patients (19 M, 10 F); aged between 3 to 16 years (mean 8.9 years) who attended Department of Physical Medicine and Rehabilitation from Jan 1992 to Dec 2003 were included in this study. Out of 29, 13 children were delivered at hospital; rest 16 children at home. Fourteen cases were born premature; remaining 15 were full term. There was one case of instrumental delivery.

Inclusion criteria for this study were:

- Cerebral palsy with spastic diplegia.
- Popliteal angle more than 40^0
- Presence of kneel standing balance.

Patients with the following conditions like ilio-psoas spasticity, mental retardation, hearing impairment, visual impairment were excluded from this study. Cases which were previously operated by neurectomy, tendon transfer etc. were also excluded, except in two cases. Presence of calf spasticity and ankle clonus was not considered as contraindication.

Method

Surgery was performed in prone position under GA. Fifty-eight limbs of 29 patients were operated. Both the limbs of the same patient were operated simultaneously by two teams under tourniquet. The hamstrings tendon insertions and tendinous origins of gastrocnemi were exposed through a horizontal incision at popliteal crease. Tendons of semi-membranosus and biceps femoris were divided near the insertions and secured with stay sutures. Short head of biceps was resected from the tendon. Tendon of semi-membranosus was lengthened by z-plasty or fractionally lengthened according to the degree of tightness. Superficial halves of tendinous origins of gastrocnemi were sliced off and reflected proximally (Fig.1). Tendons of semi-membranosus and biceps femoris were fixed to the reflected origins of gastrocnemi (Fig.2). Wound was closed in layers and long leg plaster cast was applied.

TA tightness or / and calf spasticity were released in the same sitting by lengthening or selective tibial neurectomy in 5 cases in addition to the above procedure to prevent genu- recurvatum and stiff knee gait.

Post-operative care

At 3 weeks, cast and sutures were removed. Active hip extension, knee flexion and ankle dorsi-flexion exercises were done with manual assistance in few weeks after removal of cast. Retraining of transferred tendons by faradic stimulation was also started during this period. Standing and weight bearing were started after 4 to 6 weeks after surgery. When standing balance was achieved, patients were allowed to walk inside parallel bar.

Results

Patients were assessed at 6 weeks; 3 months; 6 months; 1 year after surgery. Minimum follow-up period was 1 year and maximum 10 years (Mean 5.6 years). Of 29 patients, 5 were lost to follow-up; hence, only 24 patients were assessed as per following criteria:

- Decrease in popliteal angle: Pre and post operative values were recorded. Average values of right and left were plotted for each patients in chronological order of timing of operation as in Diagram 1a. Grading was done according to the degrees of reduction of post-operative measure compared to pre-operative value of this angle; poor – less than 15^0; fair - more than 15^0, less than 30^0; good – more than 30^0 and less than 40^0; excellent – more than 40^0 or normal post – operative Population.
- Increase in hip extensor strength: Hip extension was tested while the patient was in prone position. Power was graded in MRC scale 1 to 5. Difference between pre-operative and post-operative measures were plotted as in Diagram 1b. Grading of result was done as: poor – no improvement in grade; fair – 1 grade improvement; good – 2 grade improvement; excellent – 3 grade improvement.

Improvement of Balance: Scores were assigned to the level of balance achieved pre-operatively and post–operatively as follows: kneel standing with minimal support – 1; kneel standing without support – 2; kneel walking – 3; single leg standing with support – 4; single leg standing without support – 5. Pre and post-operative values were plotted as in Diagram 2. Grading was done as in hip extensor.

Global assessment of gross motor function : This was done by observing (i) decrease of hip flexion, (ii) decrease of knee flexion during stance and swing and dorsiflexion or decrease of plantar flexion during swing. Grades were given as poor, fair, good and excellent.

The patients were assigned a particular grade if he scored the same grade in at least three categories. Accordingly, 6 patients were graded as excellent; 16 as good; 2 as fair. There was none in poor grade.

Minor complications like stitch infection in two patients, painful nodules at the site of tendon attachment in six were managed conservatively. There were two cases of genu-recurvatum; of which one was severe, needing KAFO; other needed AFO. Both were able to walk without pelvic tilt with support of crutches. Knee flexor weakness was observed in all cases in the first six months after operation. However, we observed that all patients achieved knee flexion at least 3/5 at six months and none had disability on this account.

Discussion

Crouch gait is the most resistant condition to treat in the diplegic spastic cerebral palsy. Crouch complex consists of flexion at hip and knee; planter flexion at ankle. Weakening of hamstrings to reduce knee flexion which is the most important component of crouch is the commonest technique used to treat this condition. Partial distal lengthening of medial or lateral

hamstrings;[4,5,6] total distal lengthening;[7,8,9,10,11,,13,14,15,16] and proximal hamstrings lengthening[17,18] by fractional lengthening or z-plasty are reported recently. Partial lengthening usually leads to re-appearance flexion attitude[8].Whereas, total release is associated with incidence of pelvic tilt [6,7,19] and genu-recurvatum[4,7]. Pelvic tilt is due to weakness of extensor of hip, even if there is no spasticity or contracture of ilio-psoas. Hoffinger and Abou Ghaida[19](1993) had shown that Hamstrings function as important hip extensor in CP diplegics as shown by dynamic electromyography of hamstrings. Other method of weakening of the hamstrings is by injection of Botulinum toxin in the hamstrings[20] This effect of toxin is at the best and temporary and last only for few months and this is costly. Hence, transfer of distal hamstrings to lower femur relieves pelvic tilt as it will function as hip extensor. Egger's operation is total transfer of distal hamstrings to femoral condyles without leaving any muscle to flex the knee[1]. Hence, genu-recurvatum is the common complication of this operation. We transfer only Semi-tendinosus and Biceps femoris; leaving Semi-membranosus to act as knee flexor. Semi-membranosus appropriately lengthened to prevent knee flexion; to reduce popliteal angle at the same time.[3,8,13,15]

In original Egger's operation fixation of tendons to the posterior surface of femoral condyles is technically difficult as it lies in the deeper plane[1] and presence of popliteal vessels, genicular arterial anastomosis is the cause of significant bleeding in this operation. In our technique tendons are attached indirectly to femoral condyles through tendinous origins of gastrocnemi which is attached to the femoral condyles. Hence surgery is practically same as distal lengthening of hamstrings, taking no more operating time. Ray and Ehrlich (1979)[3] transferred tendons of Semi-tendinosus and Semi-membranosus to lateral inter-muscular septum and tendon of Biceps femoris respectively with good results in relieving knee flexion attitude. In our technique, emphasis is more on hip extension than decrease of popliteal angle Of the important complications reported by other workers, like knee flexor weakness,[11] genu-recurvatum,[3,4,7] lack of knee extension,[9,10,12] we enounter hamstrings weakness in 9 cases; 2 cases of genu-recurvatum; none of the last. However, all the nine cases of hamstrings weakness achieved 3/5 power at six months after operation.

Conclusion

Partial transfer of distal hamstrings using semi-tendinosus and biceps femoris to femoral condyles through tendinous origins of gastrocnemi, combined with appropriate lengthening of semi-membranosus is effective in relieving crouch gait in cerebral palsy with spastic diplegia. Operation is technically same as any type of distal hamstrings lengthening. Serious complications of both hamstrings lengthening and transfer are avoided in this technique.

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Epidemiology and Rehabilitation of Hip Fractures in the Geriatric Population.

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Abstract

Hip fractures are the leading cause of morbidity and mortality in the elderly population. The purpose of this study was to identify the risk factors along with effective rehabilitation measures for the hip fractures in elderly age group. Data was collected over a period of two years on 176 geriatric patients with hip fractures presenting to our institute. Demographic information, medical history, mobility and environmental factors were recorded along with the intervention and also the complications encountered. 59% were intertrochanteric fractures while the rest (41%) were intracapsular neck fractures. Majority of them were treated surgically and only 4% managed conservatively. Special effort was made to mobilize the patients as early as possible and prevent complications. The functional recovery of the patients after one-year post surgery was noted (70%) and conclusions made. Effective prevention of the risk factors along with vigorous and early rehabilitation helps in early recovery of hip fractures in elderly population.

Key words : **hip fractures, geriatrics, rehabilitation, mobility**

Introduction

In the geriatric population, fall is the leading cause of nonfatal injuries and hospital admissions[1]. Among the fall related fractures, hip fractures lead to the most severe health problems and reduced quality of life thus causing the greatest number of deaths. [2,3]. The medical cost of these injuries, in the elderly age group, is also very high. A hip fracture is generally a fracture of the proximal femur. Such injuries may be divided into three categories, according to the anatomical area in which they occur. Femoral neck and intertrochanteric fractures account for over 90% of hip fractures, occurring in approximately equal proportions and subtrochanteric fractures account for the remaining 5-10%. Given our aging population, the number of hip fractures is expected to increase dramatically in the next decade. While rehabilitation interventions to decrease the risks of falls and thus prevent hip fractures are of utmost importance [4], post fracture rehabilitation care is also crucial. These interventions should be initiated within the initial few postoperative days and continued until the individual has maximized functional skills within the community. A thorough understanding of the newer treatment settings, available resources and the appropriate medical and rehabilitation strategies is necessary to minimize post fracture complications. A combination of orthopaedic surgery and early postoperative physical therapy is usually the best approach. The overall goal in the treatment of the geriatric hip fractures is to return the patient to the premorbid level of function. [5-8].

This study was undertaken to understand and respond more effectively to the needs of the hip fracture patients. The specific aim was to find the risk factors in hip fractures and to determine the effectiveness of adequate rehabilitation on functional recovery of the patients.

Materials and Methods

A total of 198 patients admitted with recent hip fracture at our tertiary level health institute were evaluated in this retrospective study. The study period extended from 2002-2004. To be included in this study, patients had to be 60 years of age, or older, ambulatory and should have sustained a fracture of non pathological origin. A total of 22 patients were excluded because of pathological hip fractures. All the required demographic information was collected preoperatively. Information on functional status, living circumstances, and ambulatory status were reviewed and obtained from the patient or their relatives. General health status was defined by a number of preexisting significant comorbid condition including asthma, cardiovascular disease, angina, myocardial infarction, stroke, congestive heart failure, COPD, hypertension, diabetes mellitus, seizures or previous fractures. Assessment of basic activities of daily

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living was adapted from the method of Katz coworkers [9]. It was classified as independent or dependent on each of the four basic activities of daily living, bathing, eating, toiletry and dressing with response grading from ability to do it alone to being completely dependent.

To assess the role of severity of health problems at the time of admission, ASA classification was used [10]. All preoperative radiographs were examined for fracture type, displacement and comminution. The fractures were classified as either intertrochanteric, intracapsular or subtrochanteric. All patients were attempted to be treated surgically with open reduction and internal fixation as early as possible but night –time surgery was avoided. The patients with intertrochanteric fractures were treated with a dynamic hip screw and plate system. The patients with femoral neck fractures were treated with cancellous screw fixation, Austin Moore's, Thompson endoprosthesis or bipolar arthroplasty. Postoperative radiographs were reviewed to determine the treatment rendered and result obtained.

The standard post surgical rehabilitation consisted of chest physiotherapy and quadriceps exercises on the first day after surgery, progressing to daily active assisted exercises. Patients with stable fractures were out of bed on the second day after surgery and began ambulating daily with weight bearing as tolerated. Patients with unstable fractures were required to remain non weight bearing for six weeks. All the complications encountered during the patient's stay in the hospital were recorded. All patients were scheduled for follow up visits in the orthopaedic clinic at six weeks, three, six and 12 months after hospital discharge.

Results

This study of 176 patients enrolled during the two year period included 118 (67%) males and 58 (33%) females. The average age was 63 years for men and 65 yrs for women, with an overall average of 63.5 years. There was no major difference in the age between men and women. Interviews were conducted directly with the patient. As expected, most patients had a history of other medical conditions before hip fracture. The most prevalent were arthritis (63%), hypertension (60%), diabetes mellitus (32%), heart disease (30%) and cataract (30%). 27% patients reported previous fractures. Neurological conditions were common with 15 % of patients having a previous stroke and 8% having Parkinson's disease. Physical limitations as revealed by impaired mobility, were present in most patients. 54% patients described having difficulty in at least one of the common mobility tasks of daily living. Most of the falls occurred indoors, only 28% of the falls occurred outside. The most frequent sites indoors for the falls were the bedroom (20%), living room (17%) and kitchen (14%). Sixty percent of the falls occurred during daylight hours, but lighting was believed to be adequate at the time of the fall in 85% of the patients. In 40% of the falls the patient slipped or tripped. For 33% of the patients, an endogenous cause (weakness, dizziness) was responsible for the fall. Intertrochanteric fractures were seen in 104 patients (59%) and intracapsular femoral neck fractures in 72 patients (41%). The fracture configuration was not related to activity at the time of fall, or location of fall. Nearly all intertrochanteric fractures were treated by open reduction and internal fixation (ORIF) with dynamic hip screw and plate fixation and all but one intracapsular

Table-1: Gender And Age Distribution Of The Study Group

Age (years)	Male	Female	Total
60-70yrs	72	32	104
70-80yrs	34	20	54
80yrs & above	12	6	18
Total	118	58	176

Table-2: Relationship Of Fracture Pattern With Gender, Age And Treatment Options

	Intertrochanteric #	***Intracapsular #***	***Total***
Male	68	50	118
Female	36	22	58
Age (years)			
60-70	61	43	104
70-80	33	21	54
80<	10	8	18
Overall	104	72	176
Treatment regimen			
ORIF	98	18	116
Endo/THA	—	53	53
Conservative	6	1	7

Table-3: Incidence Of Postoperative Complications

Complications	*Number (%)*
Urinary Tract Infection	24 (14)
Chest Infection	17 (10)
Congestive Heart Failure	12 (7)
Deep Venous Thrombosis	8 (5)
Operative Wound Infection	8 (5)

fractures were operated upon. 7 patients (4%) were treated nonoperatively because of severe medical problems that precluded surgical intervention. 24 patients (14%) developed urinary tract infections during their hospital stay. Deep venous thrombosis was seen in 8 patients. Pneumonia and other chest related infections were noted in 17 (10%) patients and CHF in 12 patients. The mean hospital stay was 18 days with the median length of stay being 14.7 days. The duration of hospital stay was more in patients who had more comorbid conditions or those who developed complications post surgery.

Patients were mobilized as early as possible, with most of the fractures being mobilized on postoperative day one. No mortality was observed in the subject patients during their hospital stay. By the end of one year, nearly 70% had returned to their basic activities of daily living.

Discussion

Hip fractures are the leading cause of morbidity and mortality in the elderly population. Various studies have been conducted to evaluate the factors playing a role in the falls and subsequent fractures [11-13]. The current study was designed to identify the medical, social and environmental milieu surrounding the elderly patient with a fractured hip and also to evaluate the complications associated with an aim to prevent them in future. In our study, there was a high prevalence of associated medical conditions like cardiovascular, neurological conditions. They have been shown to be potential risk factors for falls and fracture of the hip in various studies [14]. These conditions have an affect on the general condition of the patient and hamper early surgical intervention. Patients with out any comorbid conditions were taken up for surgery earlier and also discharged earlier than other patients.

Most fractures are caused by stumbling and tripping which usually occurs indoors at a level ground. This was further reaffirmed in our study as already reported by a number of authors before[12-15]. Proper assessment of the subjects' environment at home should therefore be done. During rehabilitation, physical impairments should be addressed first. Patients should wear hip protectors, which help prevent hip injury caused by a direct fall from a standing position [16]. Periodic review of the patient's prescription and other medications is also imperative so that psychotropic drugs and sedatives may be avoided as much as possible [14]. A firm understanding of the individual's premorbid characteristics and habits is therefore vital. Special considerations are also necessary to address mobility deficits in the older adult with hip fracture, including alterations in vision, decreased peripheral sensations, age related imbalance, decreased strength and limited physical endurance. Recovery of motor and balance function tends to occur more slowly in the older adult, owing to premorbid limitations, decreased tolerance for therapy and joint or musculoskeletal pain. Lastly the concept of safety awareness, or an individual's understanding of his or her limitations, need to be further examined [17-18]. The current study advocates attention to well established fall-risk factors to obtain the greatest accuracy in predictive judgments and adoption of realistic expectations about our ability to predict this unfortunate event.

Although the primary goal of rehabilitation is clearly to restore premorbid function after hip fracture, methods to do so are less well established. This study focused on improving functional outcome of hip fracture patients through intensive rehabilitation efforts. Patient outcomes are determined primarily by the success of the orthopaedic repair, by patients preexisting cognitive impairments, or by the strength of family support systems [19]. An intense rehabilitation program is also essential to prevent further morbidity. All individuals with hip fractures should be mobilized out of bed as early as possible. For the majority of patients, this can begin within 24 hours of surgical intervention. We found in our study, beneficial effects of early mobilization with decreased postoperative complications.

Prevention of thromboembolic complications (deep venous thrombosis or pulmonary emboli) is critical after a hip fracture. An important component of this effort is early mobilization, which decreases venous stasis in the legs. In our study, 8 patients had deep venous thrombosis, in spite of prophylactic antithrombotic medication in high risk cases. The current trend is for patients to receive prophylactic medication based on a careful assessment of the patient's risk factors and the physician's preference.

In our study, the most common postoperative complication was urinary tract infection Change in routine, lack of exercise, poor hydration were the various compounding factors along with catheterization [20]. Constipation is also a frequent postoperative complication in the elderly. Opiod analgesics and calcium supplements are the usual causes for constipation after hip fractures.

Hence, adequate hydration, scheduled toileting facilitates return of normal bowel and bladder functions.

In our study, no objective test for evaluation of osteoporosis was used. In general, it has been estimated that 70% of hip fracture are due to osteoporosis [21]. Hence, as a matter of routine prophylaxis, all geriatric patients should have an intake of adequate amount of calcium supplements and vitamin D daily. Weight bearing exercises; such as walking further prevent bone loss.

A small number of our patients underwent an alternative conservative approach to surgical intervention. It consisted of a limited period of bed rest followed by gradual progression towards walker-assisted mobility. This was done in patients whose comorbid conditions precluded surgery. This is also an effective treatment approach followed by some [22,23], in which the patients with time, become pain free without operative intervention. In contrast to THR, prognosis following a hip fracture is guarded [22-24]. Miller reported 51% of survivors regained their prefracture ambulatory status within a year of fracture. In our study, the functional recovery rate was higher (70%) than the rest which may be explained by the fact that majority of our patients were in the 'younger' geriatric population of 60-70 year group.

Hip fractures in the elderly are a major public health concern, causing prolonged disability, morbidity and loss of function. The demand for rehabilitation services following a hip fracture is most likely to increase in the foreseeable future. A comprehensive rehabilitation program providing evidence-based intervention along with prevention of obvious risk factors of geriatric hip fractures is therefore essential.

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Krukenberg Operation: Revisited

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Abstract

The hand serves as a highly efficient and adaptable tool capable of performing extremely delicate as well as strong tasks with ease. It is an organ not only of sensation but also of expression. Therefore, loss of hand causes more handicap than the loss of leg. It is a well-recognized fact that even the most sophisticated upper limb prosthesis cannot match the functions of hand.

In view of above, importance of Krukenberg operation, for reconstruction of non-functional below elbow stump, into a highly functional and sensate organ, to compensate for the loss of functions of upper limb, cannot be over emphasized. However, there are very few centres in the world where this operation is performed. As it requires skill and expertise to perform the operation and results are good only in expert hands.

Key Words : **Krukenberg Operation; Below Elbow Amputation, Functional and Sensate organ, Rehabilitation.**

Introduction

The hand is one of the most complex anatomical mechanisms, which performs a varietiy of complex functions with minimal conscious effort. As no prosthesis can ever compensate for all functions of the hand, its loss leads to devastating consequences. Loss of one-hand results in severe degree of handicap and it increases exponentially with loss of both the hands (1).

Amputee rehabilitation is not solely the provision of prosthesis rather it is the restorative intervention necessary to return the patient who has had an amputation to the highest level of functioning to minimise the impact of amputation on his or her life (2).

In 1917 Krukenberg described a technique that converts a forearm stump into a pincer that is motorized by the pronator teres muscle. In this operation radius and ulna are separated into the two jaws of a “crocodile” forceps, with tactile sensibility. Indications mostly include bilateral upper-extremity amputations, especially in those who are also blind. The procedure has also been used successfully in developing countries who lack the means to obtain expensive prostheses (3).

This procedure preserves proprioception and stereognosis in the functional stump to allow for effective

maneuvering in the dark. It is important to note that this procedure is not recommended as a primary procedure at the time of an amputation, and the procedure must be preceded with appropriate counseling due to cosmetic concerns. Conversely, once this procedure is performed, it does not preclude the use of a functional prosthesis. Therefore, the patient is offered the option to use either functional strategy (4).

To consider this surgical option, the ulna and radius must extend distal to most of the pronator teres (the motor for pinching) and an elbow flexion contracture if present

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should be of less than 70°. Swanson and Swanson, Nathan and Trung and Garst described several modifications of Krukenberg's original surgical technique, focusing on conservative debulking and flap closure without the need for skin grafts. The success of this procedure depends directly on the strength of the pronator teres, the sensibility of the skin surrounding both ulna and radius, elbow mobility, and mobility of the ulna and radius at the proximal radioulnar joint. Individual patient expectations and motivations, although more difficult to assess, probably play a major role in outcomes as well (5).

Material & Method

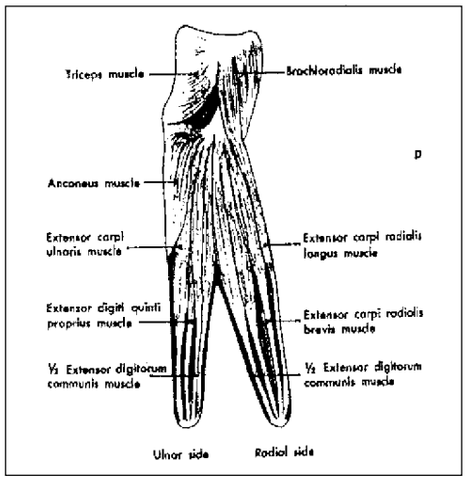
A total of eighteen below elbow amputees underwent Krukenberg operation at Artificial Limb Centre, Pune in a period of six years from Jan 1998 to Dec 2003. These patients were evaluated for their suitability for Krukenberg procedure. Prerequisites for Krukenberg procedures were: -

(a) Below elbow stump should have minimum length of 20 cm.

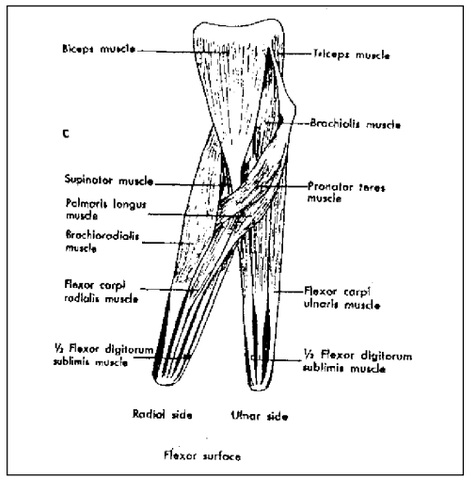
(b) Stump should exhibit full range of flexion, extension, supination and pronation, with good strength.

c) Stump should have fully functional pronators.

Pre-operatively below elbow amputation stump, was examined thoroughly for adequate vascularity, availability of healthy skin, adequacy of length, strength of muscles and movements at elbow and radio ulnar joints.

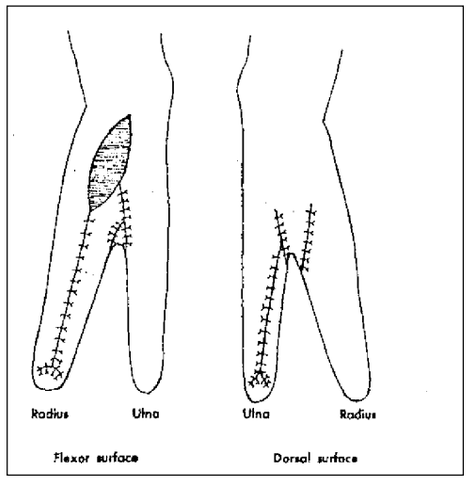


For ideal Krukenberg stumps, length of base from elbow crease should be 8 cm and length of two prongs should be 12 cm from base. The skin incision was placed 1 cm medial to midline anteriorly. The incision was turned laterally by 90° at its proximal end. On the posterior aspect, the incision was made in the midline and its proximal end was turned medially at right angle. Distally, both incisions were joined in midline at tip of stump.



Incisions were deepened and muscles were separated into two equal halves. The flexor digitorum sublimis and flexor digitorum profundus were also separated by blunt dissection. A similar procedure was carried out on posterior aspect.

Interosseous membrane was divided to separate radial and ulnar prongs gently. Precaution was taken to avoid injury to Interosseous vessels.



Both bones were divided at the same level. The muscles were sutured over the tip of the bones. Radial stump was closed by 'Z' plasty. A split skin graft was placed to close ulnar stump without tension. Suction drain was placed separately in both stumps and operative wounds were dressed keeping both prongs separated as much as possible. Drainage tubes were removed on third day. First dressing was changed on fifth day and second on tenth day. Skin sutures were removed after 2 weeks.

Training was started immediately after wound healing, to re-educate movements of pronation and supination in closing and opening movements of the radial and ulnar stumps to achieve pincer and grasping effects. All patients were given training in activities of daily living and for other works.

Results

Most of our patients were young male of 25-35 years (61%)[Table 1]. Thresher injury was the main cause of below elbow amputation in the patients who underwent Krukenberg operation (33 %) followed by frost-bite (28 %)[Table 2]. 33 % of the cases were bilateral below elbow amputees [Table 3]. Postoperative skin flap necrosis developed in33 % patients, while 5.55 % of them developed necrosis of tip of bones [Table 4]. 17 % patients had temporary loss of pincer action of Krukenberg stumps. In these cases pincer function improved by electric stimulation of pronator teres muscle. Results were satisfactory in all cases as no patient developed permanent loss of pincer effect [Table 5].

TABLE 1. AGE DISTRIBUTION

S. No.	*AGE*	*No*	*% OF CASES*
01.	15-25 Yrs	4	22.22%
02.	25-35 Yrs	11	61.11%
03.	Above 35 Yrs	3	16.67%

TABLE 2. CAUSES OF AMPUTATION

S.No.	*CAUSE*	*No*	*% OF CASES*
01.	Road Traffic Accident	3	16.67%
02.	Blast Injury	3	16.67%
03.	Gangrene	1	5.55%
04.	Frost Bite	5	27.78%
05.	Thresher Injury	6	33.33%

TABLE 3. LATERALITY

S. No.	*SIDE*	*No*	*% OF CASES*
01.	Unilateral	12	66.67%
02.	Bilateral	6	33.33%

TABLE 4. POST OPERATIVE COMPLICATIONS

S. No.	*COMPLICATION*	*No*	*% OF CASE S*
01.	Necrosis of Flap	6	33.33%
02.	Necrosis of tip of bone	1	5.55%
03.	Temporary loss of Pincer action of prongs	3	16.67%
04.	Permanent loss of Pincer effects of prongs	Nil	Nil

TABLE 5. OUT COME OF OPERATION

S. No.	*OUTCOME*	*GOOD*	*SATISFACTORY*	*POOR*
01.	Pincer effect of prongs	66.67	33.33%	Nil
02.	Ability to do activity of daily living	61.11%	38.89%	Nil
03.	Sensory perception by prongs	100%	-	-

Discussion

Amputation continues to represent a major health and socio-economic problem. In Western Countries, vascular insufficiency and diabetes make major etiological groups (6,7), while in our country trauma is the major cause of amputation (8). Accident is the main cause of the upper extremity amputations and most of these occur in young males (9).

Loss of hand results in lack of grasp and sensation. The higher the level of amputation, greater is the functional loss. An upper limb with limited motion, multiple sears or lack of sensations, functions poorly because of the constant risk of tissue injury. This type of limb often functions worse than a modern prosthetic replacement (10).

Loss of one hand results in severe degree of handicap. It not only causes physical disablement but also leads to social, psychological and economical handicap (11). Handicap is multiplied with loss of both hands.

The Krukenberg procedure of converting two non-functional below elbow stumps into sensitive and functional organs make double hand amputee a totally independent individual. In such an amputee who has also lost his vision, the procedure is of vital importance (12). Krukenberg devised this procedure in 1917. However, the procedure fell in to disrepute due to its

unsightly appearance but its functional capabilities overshadowed all its negative points (13). The Krukenberg operation has been performed regularly at artificial limb centre, and more than 200 operations have been done since 1950(14).

Ratio of upper limb to lower limb amputation, in USA is 1: 4.9 (15), while it is 1: 9 in India. In UK, arm amputation accounts for only 3 % of the total amputation referred for prosthetic rehabilitation.

The most frequent causes of upper limb amputation are trauma and cancer followed by vascular complication of disease in USA (16). In our Country more than 2/3 upper limb amputation are due to trauma. The most common upper limb amputation is at the trans-radial level, which account for 57% of all upper limb amputations. Trans-humeral amputation accounts for 23% of all amputations. The right hand is more frequently involved in work related injuries.

Krukenberg operation is rarely performed in Great Britain. It has been more commonly performed in Germany and India with good results (17). Schmidt A et all (Shriner's Hospitals for Children, Los Angeles) found that although medical practitioners in North America consider the Krukenberg procedure to be too unattractive to outweigh the superior functional results, non-medical people do not share this opinion. Thus, medical practitioners should offer the procedure as a viable option to prosthetic use and allow each patient (and family) to come to their own decision (18).

Conclusion

Results of Krukenberg reconstructive procedure on a below elbow stump to provide grip, grasp and pinching mechanism with sensation have been found to be so gratifying that the patients disregard the alleged poor appearance and most patients accept the Krukenberg procedure.

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IJPMR April 2005; 16 (1) : 24-28 *Technical Note*

Fabrication of Total Contact Socket Made up of High-Density Polyethylene using Vacuum Forming Technique with Below-Knee Exoskeletal Jaipur Prosthesis

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Introduction

Prior to the development of total contact socket for below knee prosthesis, the majority of below knee sockets did not provide contact between the end of the stump and socket. From a biomechanical standpoint, the total contact socket is generally preferable because it offers the following advantages:

1. As total contact socket is in contact with lower surface area of the stump it provides better sensory feedback.
2. In immediate post-operative period, it prevents edema and aids in venous return.
3. Although the major weight is borne by patellar tendon & medial tibial flare, the total contact socket provides larger area over which load is distributed.
4. It increases the proprioception.

Several materials have been used from time to time to fabricate total contact socket, which includes leather, wood, thermosetting composites, thermoplastic etc.

A long-term appraisal has revealed some of the constraints, which are related to thermosetting composites. Once the resin is cured, no major alternation is possible. If the socket is ill fitting then whole of the socket will have to be re-made which will add to the cost of manufacturer and ultimately to the patient. Resins may also cause skin allergic reaction to the amputees.

High-density polyethylene (HDPE) is a thermoplastic polymer consisting of literally hundreds of composition, based on polymers of different molecular weight, branching co-polymers cross linking polymers with additives. High-density polyethylene of 95% crystallinity and 0.95% density exhibits a high melting point, higher tensile strength and greater hardness. It is lighter in weight, has higher mechanical strength than other thermoplastics. It is corrosion and chemical resistant, does not absorb moisture.

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Melting point of high-density polyethylene thermoplastic is 125º-133ºC. It can be thermoformed easily and corrections can be made (easing out of pressure points) by simply heating it with a heat gun. It is free from allergic reaction, has a desirable degree of flexibility, abrasion resistance, easy availability of the material in local market and is manufactured indigenously.

There are some disadvantages with this material however. High-density polyethylene in pure form is very brittle and very vulnerable to heavy impact and liable to crack in heavy individuals. To overcome this problem, during manufacturing of high-density polyethylene, co-polymers or some other thermoplastic material is added to reduce its brittleness. Poor ventilation and excessive perspiration in hot climate is a frequent complaint made by most of the users of high-density polyethylene total contact socket. Biggest disadvantage with high-density polyethylene is its inability to bond or to adhere to any other substance.

Since this technique is relatively new for Jaipur prosthesis, it is presented here in detail so that fabricators are facilitated to use it.

Technique

Total contact sockets were made up of 15”x15” square 10mm thick high-density polyethylene sheet for each amputee and this socket was fitted to HDPE / aluminium shank and Jaipur foot.

Material

- Cotton stockinette 6”x 1.5 metres.
- Two pre-formed POP bandages of 6”.
- Indelible pencil.
- POP paste.
- Inch tape.
- Measuring caliper.
- Mandrel.
- Wire mesh and wire screen.
- 15” x 15” high-density polyethylene sheet (10 mm thick).

- 2 Metal frames of 15”x15” (square).
- 4 Metal clamps.
- Soap stone powder: to avoid adherence between high-density polyethylene sheet and cotton stockinette.
- Pre-heated over with maximum temperature of 180ºC to heat the HDPE sheet.
- Suction machine
- Vacuum forming apparatus.
- Asbestos gloves.
- Scalpel with surgical blade attached to it to cut the excessive HDPE sheet.
- Metal file to trim off the HDPE socket.
- Hammer and iron nail: to break the positive mould inside HDPE socket.
- Cutting machine.
- Deburring knife: for finishing of the HDPE socket.
- Wall Frame to check alignment.
- LASER liner to confirm alignment.

Fabrication of total contact socket and PTB prosthesis

A. Evaluation of the stump

The stump was evaluated for joint function, muscle strength, skin condition, scarring and pain.

B. Measurements:

1. Stump Measurements

- Stump length: (a) From head of fibula to distal end of the stump and (b) From inferior edge of patella to the distal end of the stump.
- Circumferences of the stump: At mid patellar level, then after every 2” below till distal end of the stump.
- Antero-posterior dimension: Using A-P caliper, it was recorded from just below the inferior edge of patella to popliteal area.
- Medio-lateral dimension: Using M-L caliper, it was recorded from the widest area medio-laterally of the amputed knee joint.

2. Sound Limb Measurements:

Following measurements of the sound limb were taken: Length from middle of the patellar tendon to medial malleolus.

- Length from tip of the head of the fibula to floor.
- The size of foot to ascertain the size of the Jaipur foot.

C. Positive mould by “Wrap Casting” method –

Positive mould was made as described by “Radcliffe & Foort[12].

After the wrap cast was made, it was filled with plaster of paris paste. For this, the wrap was fixed in the cast holder, attached to wall frame. This cast was marked with central lines on anterior, lateral and medial sides. A mandrel and a sliding rod were chosen and separating agent like vaseline was applied over them. This mandrel was fixed in the wall frame in a way that anterior and lateral lines in the cast holder and mandrel were aligned perfectly. This alignment was re-confirmed by a LASER line. Now POP paste was poured in the wrap cast. When the plaster was set completely, the POP wrap cast was slit open and positive mould of the stump was obtained. After checking all measurements, it was ready for modification.

D. Modification of the mould – as described by “Radcliffe & Foort[12].

E. Fabrication of Soft Insert:

To make soft insert, three dimensions of the positive mould of the stumps were taken:

- Proximal circumference.
- Distal circumference.
- Total length of the positive mould.

These measurements were transferred on a 6 mm piece of ethaflex sheet. This sheet was 5” longer than the length of positive mould and ½” wider at the top and bottom than the proximal and distal circumferences of the stump. The edges of the sheet were then beveled using a belt grinder, on the opposite sides and glue was applied on both ends. When it is completely dried, both ends are pasted together and pressed by gently hammering the surfaces. Thus, a cone was obtained. It was placed in a preheated oven (»110°C) for 10-15 minutes. The positive mould with mandrel was clamped in a vise. The cast was powdered thoroughly. Now the pre-heated ethaflex sleeve is pulled down snugly over the cast, making sure that it conformed closely to the distal end. A sheath was pulled over this and vacuum was applied. The distal end of the soft insert was then bevelled.

A cap was made to cover the distal end of the soft insert. It was made by cutting a round disk from a 6 mm thick sheet, 2-3 cms larger than the exposed distal end of the cast including the bevelled edge of the liner. This disk was heated at 110°C in the oven and moulded over the distal end of the model. Carefully excess of the beveled edge was trimmed off, without shifting the cap. Glue was applied to the inside of the cap. After drying of the glue, this cap was bonded to the distal end of the stump.

F. Fabrication of total contact socket made up of high-density polyethylene sheet by vacuum forming technique

- A 15"x 15" high-density polyethylene piece of sheet (10 mm thick) was cut from high-density polyethylene sheet.
- It was fixed between 2 metal frames of same dimension (15"x15") with the help of metal clamps.
- It was placed on a stockinette (unfolded) and soap stone powder was sprinkled between sheet and stockinette fabric so that sheet did not stick to fabric.
- It was placed in a pre-heated oven at 180°C for 20 minutes. At this temperature high-density polyethylene started melting (melting point of high density polyethylene thermoplastic is 125º-133ºC).
- As it reached melting point it, became transparent. This property is of great help in recognizing that the sheet was ready for thermoforming.
- The mould with mandrel was placed in inverted position over the metallic platform of the vacuum forming apparatus.
- A nylon sock or stockinette was put over the stump model so that a smooth inner surface of socket could be attained later.
- The oven was switched off as the sheet becomes transparent.
- 2 persons wearing asbestos gloves, took out this heated sheet, with each person holding two ends, off the oven. This sheet was held over the mould.
- The sheet was allowed to hang in the air, forming a bubble.
- Great care was taken that the sheet fell itself on the mould rather than "pulled down" by persons. Otherwise the socket obtained could be of unequal thickness.
- The suction apparatus is needed to be handled carefully. Instead of switching it on totally at once, it was switched on and off as rapid burst. This method helps a great deal in preventing wrinkling and uneven thickness of the socket and getting perfect approximation of the sheet over the mould.
- The sheet took the shape of stump model as vacuum is created with the help of suction apparatus.
- Now the excessive area of the socket, which was to be trimmed off, was marked with the help of pencil:
  1. Anteriorly, the wall of the socket extended up to lower 1/3rd to lower ½ of the patella.
  2. Medio-laterally the socket walls covered the medial and lateral femoral condyles respectively.
  3. Posterior wall was of unequal height at medial and lateral ends to accommodate medial and lateral hamstring tendons in the socket. So, the medial side of the posterior wall was lesser in height as compared to the lateral side.
- The stump mould (inside the socket) was then broken off with the help of mallet and nail.
- The socket was shaped properly with the help of cutter chisel, file and deburring knife.
- After trimming off socket, amputee was made to wear this socket for trial.

G. Extension of the socket

- Next stage was fixing of the total contact socket in the exoskeletal HDPE prosthesis. First, trial of the socket on the amputee was taken, by making them wear this socket. This was to ascertain that the trim lines were correct and amputee was comfortable with the fitting of the socket.
- Amputee was asked to stand in a frame, wearing the socket keeping the pelvis level. With the help of trisquat, a line was drawn on the center of the thigh extension over the anterior surface of the socket. This line described about the varus (adduction) and valgus (abduction) in the stump and was used as a guide while extending the positive mould.
- A similar line was also drawn on lateral aspect of the socket. This line showed the amount of flexion in the stump.
- Using a wall frame, now the socket was fixed in a cast holder with its reference lines in vertical position. Any inclination can be corrected by loosening the nut in the alignment coupling and adjusting the cast holder accordingly. After adjustments, the nut was tightened.
- A mandrel was fixed at the upper end of the wall frame, conforming to the anterior and

lateral alignment line. A pre-formed shape of the limb was sleeved over it keeping this mandrel in the center of this preformed model. The POP paste was poured now into the preformed model to fill it completely.

- As soon as this hardened, the preformed model was removed, thus obtaining a positive mould of the exoskeletal B-K limb with total contact socket in complete alignment.
- It was ensured that the diameter of distal end of the mould matched with the diameter of the malleolar region of the Jaipur foot.

H. Fabrication of the HDPE shank

- A 24" long HDPE pipe having diameter of 90 mm was covered with B-K stockinette both from inside and outside. It is important to cover the pipe in this fashion in order to avoid sticking of the same. It was kept in the preheated oven at 180-200°C temperature for about 20 minutes.
- When pipe became malleable, it was pulled over the positive extended mould.
- The heated pipe was then given the shape of the mould by hand moulding. The hands continued working for a few minutes until pipe became partially cool. The extra material was cut off from both ends. When the pipe was completely cooled off, the plaster of paris inside was beaten out either by using a hammer or by using pneumatic chisel.
- The cutting and finishing was done as per trim lines of inner socket. For better smoothness of the edges, it was always suggested to use buff wheels, which can be fixed with drill machines. The HDPE shank with total contact socket inside (assembly is known as double-wall socket) was now ready for trial on the amputee and fitting of the Jaipur foot.

I. Trial & Fitting with Jaipur Foot

- The amputee was asked to wear this double-wall socket and to flex and extend the stump several times. The posterior brim of the socket was made so as not to hurt the popliteal area when it was flexed to the maximum extent.
- Amputee was then asked to stand erect with the help of supports. A pencil mark was put on the double-wall socket at the level of medial malleolus of the sound limb. This was matched with recorded measurement of head of the fibula to medial malleolus of the sound limb. The excess of distal end of the socket is cut from this mark.
- Distal 3" area of the double-wall socket was heated to make it malleable and to hold the Jaipur foot when it was cooled down.
- The Jaipur foot is now inserted in the heated area and amputee was made to stand wearing the prosthesis. The rotation of the Jaipur foot was checked.
- After checking the length of the prosthesis, the socket-foot assembly was further secured with four screws on each side of the distal end of the socket. A small portion of the screw was hammered, one drop of feviquick glue was applied on the threaded portion and the screws then, were tightened with a screwdriver.
- Leather suspension belt was pasted and riveted on the proximal end of the socket and now the prosthesis was ready to wear by the amputee.

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Thoughts on the Management of Osteoporosis

Last few years have seen a lot of change in the understanding of osteoporosis. From what was given as just a few paragraphs in the text books it is now finding a lot of importance in the literature. The whole world is seeing a sea change. Both the diagnostic as well as the therapeutic avenues widening with much clearer guidelines on doing what investigation and giving which medication. The literature is adding to the knowledge year after year, specially the last three years have been very delineating.

Diagnosis of osteoporosis now is not just based on osteopenia seen on the X-ray film. Authentic tests using nothing less than Dual Energy X-ray Absorptiometry (DEXA) scanning with clear guidelines on when to do the test are now available. It is recommended that DEXA scanning should be done to measure bone mineral density (BMD) for all above 60 years irrespective of the risk factors for the causation of osteoporosis and earlier if one or more of the risk factors for the causation of osteoporosis are present. It has been seen in practice that many practitioners start medications other than calcium and vitamin D even when the BMD is rated as normal. If the t-scores (compares the patient's BMD to that of healthy young adult) is within -1 standard deviation of a young adult (SD), it is considered normal; when the scores are between –1 to –2.5 SD, it indicates osteopenia and when the scores are below –2.5 SD it is called osteoporosis. Osteoporosis is considered severe if there are added fragility fracture(s) with BMD scores below –2.5 SD. BMD should be measured atleast at two sites to make a diagnosis. BMD results may be fallacious due to sclerosis of the bones following healing of the fractures or added osteophytosis due to degenerative changes. One word of caution, however, the standards of the peak bone density in the young adult have to be evolved in the local settings and should not be just copied from the western figures, since the measurements are relative to a population and cannot be accepted universally. Since BMD measurements have become rampant it has been found that hardly any laboratory doing this testing has developed standards based on local population. This fact must be kept in the mind and those having some say or control over labs doing DEXA scanning should be promoted to develop the standards for the normal population so that the measurements become more authentic. It need not be emphasized too strongly that in the diagnosis of osteoporosis one should rule out other conditions that may cause osteoporosis secondarily. Diagnosing osteoporosis involves ruling out other illnesses. Clear guidelines on the management of osteoporosis in children are not available.

Role of calcium and vitamin D has been through certain controversies too. Most studies do advocate adequate calcium and vitamin D supplements, both for prevention and treatment of osteoporosis. In addition, one should always keep in mind the amount of dietary calcium one is taking to calculate the actual requirement rather than giving supplements only. In our practice it has been found that higher intake of calcium supplements leads to higher incidence of urinary stones compared to moderate intake of calcium supplements in addition to reinforced dietary regimen to include adequate dietary calcium. Calcium taken as citrate can be taken independent of meals and is absorbed better compared to the carbonate salts. Besides, care should be taken to see how much of elemental calcium is available in a preparation. Most preparations would contain added vitamin D. Vitamin D in its multivitamin form is considered better for out patients use rather than the active form specifically calcitriol, which is not considered a benign drug though used rather indiscriminatingly.

The treatment of osteoporosis has been revolutionized after it was found in the Women's Health Initiative (WHI) multi-centric trial that hormonal replacement therapy (HRT), which used to be the gold standard for the management of osteoporosis in women, caused more harms than the benefits. The trial, after it was stopped without completion due to serious side effects, initially advocated that the risks of HRT should be discussed with the patients on which it was likely to be started, but later it was announced that HRT no longer remains to be the treatment of choice or the gold standard for management of osteoporosis. However, there is a limited role of HRT in patients having had premature menopause or hysterectomy. In post menopausal women Raloxifene (Selective Estrogen Receptor Modulator, SERM) is the drug of choice. The recommended dose of Raloxifene was also modified from 120 mg per day to 60 mg per day, since it was found that 60 mg gives adequate protection. In osteoporosis in men and in secondary osteoporosis (say due to steroids) the drug of choice remains to be Bisphosphonates. Etidronate now is no longer considered worth considering in the armamentarium to treat osteoporosis. Alendronate is freely available in India and is being used widely. The recommended dose is 10 mg per day, though initially 5 mg per day for prevention and 10 mg per day for treatment of osteoporosis was advocated. But gradually, for prevention, its use has been limited and doubted by

most. Many practitioners have been found using 35 mg per week though 70 mg per week gives better results. Even though a daily dose of 10 mg per day is considered better and already a weekly dose of 70 mg is a compromise, 35 mg per week does not seem to show adequate response in most studies. The difficulty with the daily dose being the compliance of the patient, that reduces down keeping in view the way this drug needs to be taken in the morning on empty stomach while asking the patient to avoid lying down in bed and be upright for about 45 minutes after ingesting the medicine. In most studies, including our experience at our institution, the gastric tolerability of bisphosphonates is quite acceptable, provided it has been explained and emphasized to the patient adequately. Some practitioners have been found to ignore this precaution and it was found that patients, who were bedridden and not allowed to sit, were given this medication leading to more chances of reflux esophagitis and epigastric discomfort. In bed-ridden patients one should also consider increase in demineralization resulting in hypercalciuria thereby increasing the risk of urinary stones. The question is whether we should give Alendronate in bed ridden patients; it seems impracticable. In any case, if literature is searched, giving more calcium and vitamin D given during prolonged bed rest is counterproductive. Injectable bisphosphonates (Pamidronate) is less potent compared to Alendronate, it is popular with doctors treating bony secondaries. Care should also be taken that giving calcium around the dose of Alendronate retards its absorption, so calcium should be staggered to another meal. Painful vertebral fractures are best treated with intra-nasal spray of Calcitonin. It is rather expensive, but pain reduces dramatically, therefore, in Indian conditions, has a place provided the patient can afford it. Tetany following Calcitonin usage has been reported if the patient does not take adequate calcium supplements, therefore, it should be ensured. Flavones are also coming up but their role is yet to be established firmly. Injectable Parathormone may be considered the drug of choice of the future, but painful injections, cost and availability are hindrances for their usage in India. Perhaps we could wait for the nasal spray being developed. If the cost remains prohibitive, it might remain only a fashionable drug used by a select few patients.

How long to treat osteoporosis remains to be a changing scene. Initially, it was advocated that one should treat for about 2 years. The changes in the bone mineral density and the markers to check the bone turnover rate suggested that in six months to one year after the initiation of the treatment with bisphosphonates there is no further increase in the BMD. Besides, it was found that bisphosphonates stay in the bones for years, suggesting perhaps they are not required to be given for years together. But when treatment was stopped the studies further showed that it was worthwhile continuing the treatment for a longer period since BMD started to reduce after a while. Keeping that in mind, it is suggested that BMD should be done at the beginning, before starting the therapy and repeated initially after six months of starting therapy and then yearly. When the BMD returns to the normal range, the therapy may be continued for another six months and then stopped and preventive measures should be continued. If the BMD falls below the critical level, one should not hesitate in restarting the drug therapy.

Of course, it should be stressed to the patients to follow a good dietary and exercise schedule as well as precautions to prevent falls and thus fractures. No drug guarantees non-occurrence of fractures. Only the chance of occurrence of fractures reduces. If these facts are well understood by the treating doctors as well as the patients, confidence of the patients in following their treatment and that of the doctors in continuing to treat remains. Making the patient cent percent free of the risk fractures due to osteoporosis may not be possible despite the best treatment available on date, this needs to be understood by all.

Boom in the electronic entertainment systems, specially television, video games and computer games has attracted children to remain indoors. Lack of parks for children to play and safety concerns are also factors making children be confined to their homes and thus reducing their engagement in exercise in general which is one of the most important factors in achieving adequate BMD, peak of which occurs around 25 years of age. The consequences of this change are likely to be seen when this population ages. It, therefore, becomes very important to promote outdoor games in children, specially high impact exercises to prevent osteoporosis in the years to come.

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