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STUDY ON THE EFFICACY OF PTB (PATELLAR TENDON BEARING) CASTING WITH BOHLER'S WALKING IRON (BWI) IN TREATMENT OF NEUROPATHIC PLANTAR FOOT ULCER

Orthopaedics

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ABSTRACT

Introduction: Neuropathic plantar ulceration is one of the serious hazards to the person with anaesthetic feet who otherwise lead an active life. The entire history of a plantar trophic ulcer is dominated by mechanical factors. The results of treatment with local applications and dressings were poor indeed until putting the neuropathic foot in a total contact plaster became the standard treatment. Several offloading techniques eg. Total Contact Casting (TCC) and custom made orthoses readily available including a simple customized PTB (Patellar Tendon Bearing) cast to the affected limb and Bohler's walking iron with PTB cast may enhance the mobility, increasing patients self-esteem and finally reduce the disability. This project is a humble sincere attempt to find out the role of PTB casting with Bohler's walking iron in the treatment of neuropathic plantar foot ulcers.

Material and methods: In this Longitudinal analytical study, conducted in the Department of Physical Medicine and Rehabilitation, IPGME&R, SSKM Hospital, Kolkata between 15th January, 2012 to 14th July, 2013 (Eighteen months) 27 (n=27) patients with neuropathic plantar foot ulcer, residents of Kolkata and surrounding districts, attending the Physical Medicine and Rehabilitation OPD at IPGME&R and SSKM Hospital, Kolkata were included and studied if they fulfilled the inclusion and exclusion criteria after getting Institutional Ethics Committee clearance and informed written consent.

Results: All the data collected during this study period were analyzed by using statistical software Statistica vertsion 6 [Tulsa, Oklahoma: StatSoft Inc., 2001] and GraphPad Prism version 4 [San Diego, California: GraphPad Software Inc., 2005] . There was statistically significant improvement. Studies yielded an average rate of successful healing of 75.5% after an average of 38.7 days. PTB casting with Bohler's walking iron is effective in the treatment of neuropathic plantar foot ulcer.

Conclusion: Mostly male of 3rd and 4th decade were affected with neuropathic plantar foot ulcer. PTB casting with Bohler's walking iron is helpful to reduce ulcer depth, and ulcer area which are statistically significant (p value < 0.001). Approximately 30% of the ulcer healed quite well after the period of 3 weeks of treatment but majority of the ulcer 77.8% healed at the end of the study.

KEYWORDS

Neuropathic plantar ulceration, Total Contact Casting, PTB (Patellar Tendon Bearing) cast, Bohler's Walking Iron

INTRODUCTION:

Neuropathic plantar ulceration is one of the serious hazard to the person with anaesthetic feet who leads an active life. The only way to heal a plantar ulcer is to rest it. If the patient walks on the ulcer deepens and osteomyelitis ensues; the scarring and distortion make further ulceration inevitable until walking finally becomes impossible. The entire history of a plantar trophic ulcer is dominated by mechanical factors. It starts from trauma or excessive local pressure and is maintained by repeated minor injuries; it heals readily without special treatment if rested completely, and its recurrence can be prevented by careful regulation of stresses on the scar. Conditions involving insensitivity of the foot including diabetes, leprosy, hereditary neuropathy, tabes dorsalis, herniated nucleus pulposus resulting in neuropathy, etc. The results of treatment with local applications and dressings were poor indeed until putting the neuropathic foot in a total contact plaster became the standard treatment.

The earliest published report of casting for trophic ulcerations dates back to 1930.[1] Dr.Joseph Khan in India described an ambulatory technique for the treatment of plantar ulcers occurring in patients with Hansen's disease (leprosy) as an alternative to prolonged, expensive periods of bed rest in the hospital. The regularity and speed with which these trophic ulcers heal in a walking plaster is most impressive and support the concept that the ulceration is related mainly to mechanical factors. From the practical point of view it suggests firstly that ulceration can be prevented, and secondly that recurrence of ulceration can be avoided by the wearing of shoes which provide conditions similar to those in a plaster. Dr.Paul Brand and his associates refined and popularized the technique Total Contact Casting in the early 1960s.[2] Since then Total Contact Casting is an important mode and —gold standard among the methods used to heal neuropathic foot ulcers. Apart from Total Contact Casting there are several offloading techniques and custom made orthoses readily available including a simple customised PTB (Patellar Tendon Bearing) cast to the affected limb. Addition of walking iron with PTB cast may enhance the mobility, increasing patients self-esteem and finally reduce the disability.

There is a grey zone regarding the role of **PTB (Patellar Tendon Bearing) Casting with Bohler's Walking Iron (BWI)** in patients with neuropathic plantar foot ulcer. This project is a humble sincere attempt to find out the role of PTB casting with Bohler's walking iron in the treatment of neuropathic plantar foot ulcers.

Aims and Objectives:

To observe the improvement pattern of neuropathic plantar foot ulcers after doing the PTB casting with Bohler's walking iron.

Material and Methods: Before the start of the study clearance of the Institutional Ethics Committee was taken. Individual informed written consent was taken from each patient to include in the study group.

Study Area: Department of Physical Medicine and Rehabilitation, IPGME&R, SSKM Hospital, Kolkata.

Study Population: Patients with neuropathic plantar foot ulcer, residents of Kolkata and surrounding districts, attending the Physical Medicine and Rehabilitation OPD at IPGME&R, SSKM Hospital, Kolkata were included in the study if they fulfilled the inclusion and exclusion criteria.

Study Period: Eighteen months (15th January, 2012 to 14th July, 2013)

Sample Size: n = 27
Study Design: Longitudinal analytical study

Inclusion Criteria:
1. Grade 1 and grade 2 plantar ulceration (Wagner classification),
2. Age of the patients 18 years and more,
3. Unilateral involvement,
4. Ambulatory patients.

Exclusion Criteria:
1. Grade 3, 4, 5 plantar ulceration (Wagner classification),
2. Patients unwilling to have cast on extremity,
3. Age less than 18 years,
4. Excessive leg or foot swelling,
5. Patients unable to comply with follow up visits,
6. Patients unsafe in mobility while in cast.

Study Technique:
After getting Institutional Ethical Committee clearance those patients agreed to give their consent and also fulfilled the above mentioned inclusion and exclusion criteria were included in this study period for further assessment and intervention. The selected patients were examined at baseline first. Study parameters were also measured at the visit 1. To observe the improvement pattern the patients were identified individually with their name, address, contact number. Then treated with PTB casting with Bohler's walking iron. All the patients received education regarding routine care of the cast and warning signs. The debridement of the ulcer was done under strict aseptic condition and all the patients were advised to follow advice and report accordingly if they face any problem. The patients were examined and assessed at the interval of 1st week (visit 2), 3rd week (visit 3) and 6th week (visit 4).

Intervention:
Before the cast was applied, the ulcers were debrided off all necrotic tissue and hypertrophic edges were shaved to create a smooth transition from the ulcer's bed to adjacent skin without an intervening shelf of keratin. The wound was then cleaned with 10% solution of povidone iodine. Single sterile gauze dressing (5×5) cm was used to cover the each ulcer, in order to limit bulk and prevent excessive pressure.

PTB Casting With Walking Iron:
Position: The patient seated on the edge of a table with involved limbs knee flexed at 90 degree and the foot was steadied on a low chair with ankle at 90 degree.

Technique: After proper positioning a roller cotton 10 -15 cm wide was applied from toes to knee (up to just above of the femoral condyle). A bit of extra padding was needed over knee. Then three 15 cm and three 10 cm plaster of paris cast was applied from toes to knee extending up to superior pole of patella. Then the cast was firmly moulded round the inferior patellar ligament, femoral condyles and over medial tibial flare. The cast was moulded into a triangular shape. The anterior portion of the cast was then trimmed from the upper pole of the patella. Posterior portion of the cast was trimmed to one finger breadth below the level of the cast indentation that was made anteriorly into the patellar tendon. The posterior wall of the cast should be low enough to allow 90 degree flexion of knee without having the cast edge rub on the hamstring tendon. Then a walking iron (a simple device with two metallic vertical bars and one sole to bear weight, being made with rubber) of size 12 or 14 was fitted to the affected limb incorporating with the plaster of Paris (POP) cast.

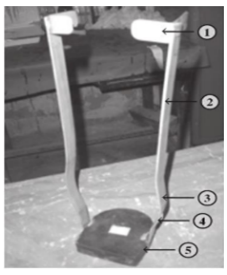

Figure 1: Bohler's Walking Iron (BWI), a simple device with two metallic vertical bars and one sole to bear weight, being made with rubber. 1. Metal cross pieces (bars), 2.Metal side bars, 3.Rounded flares of side bars, 4. Terminal part of the side bars 5. Rubber heel.

Figure 2: a patient after PTB cast with Bohler's walking iron (BWI)

Parameters studied: 1. Size (mm^2) of the ulcer. 2. Depth (mm) of the ulcer. 3. Downgrading of Wagner classification. 4. Complete ulcer healing time in weeks/days.

Assessment: In consecutive four visits - visit 1 (0 week), visit 2 (1st week), visit 3 (3rd week) and visit 4 (6th week) using the parameters mentioned above and all the data documented in our stipulated proforma.

Figure 3: Before PTB cast with Bohler's Walking Iron (BWI)

Figure 4: After 6 weeks of PTB cast with walking iron(BWI)

CASE:1

Figure 5: CASE 2 – Before PTB cast with Walking iron (PTB CAST WITH BWI)

Figure 6: CASE2 – After 3 weeks of PTB cast with walking iron (PTB CAST WITH BWI)

After that a master chart was prepared and results were analyzed.

Study Tools: Sterile gloves, Povidone iodine, Chlorhexidine, Sterile gauze piece, Surgical blade, Dissecting forceps, Measuring tape, Sterile probe(blunt tip), 5.07(10g) Simmes-Weinstein monofilament, Transparent sheet, Marker pen, Case record form, POP cast (15 cm,10 cm), Bohler's Walking iron (No. 12 or 14), Plaster cutting machine, Camera, Sphygmomanometer, Stethoscope, etc.

Investigations: 1.Blood examination: Hb%, TLC, DLC, ESR, Sugar, CRP, 2.Radiological examination: x-ray, 3.Culture sensitivity of wound discharge (if required)

Result Analysis: All the data collected during this study period were analyzed by using statistical software Statistica vertsion 6 [Tulsa, Oklahoma: StatSoft Inc., 2001] and GraphPad Prism version 4 [San Diego, California: GraphPad Software Inc., 2005]

Table- 1: Age distribution between groups (n=27)

Age in years	PTB with BWI Number of patients	TOTAL Number (%)
18 to 34	3	11.1
35 to 49	11	40.8
50 to 64	8	29.6
65 and above	5	18.5
Total	27	100%

Table- 2: Gender distribution (n=27)

SEX	NUMBER	TOTAL(%)
MALE	16	59.26
FEMALE	11	40.74
TOTAL	27	100%

Table-3: WAGNER grade of ulcer (n=27)

WAGNER GRADE	NUMBER	TOTAL(%)
Grade-1	5	18.52
Grade-2	22	81.48
TOTAL	27	100%

Table-4: Descriptive statistics of numerical variables (n = 27)

Variables	Mean	Median	Lower Quartile	Upper Quartile	Std. Dev.
AGE	51.1	49.0	41.0	60.0	13.99
Length of the ulcer(mm):					
V1_Length	23.1	21.0	16.0	31.0	8.25
V2_Length	19.7	19.0	15.0	28.0	8.20
V3_Length	10.9	14.0	0.0	19.0	8.40
V4_Length	2.7	0.0	0.0	0.0	5.25
Width of the ulcer(mm):					
V1_Width	18.1	17.0	12.0	26.0	8.08
V2_Width	15.9	16.0	10.0	22.0	7.90
V3_Width	9.3	9.0	0.0	16.0	7.80
V4_Width	2.3	0.0	0.0	0.0	4.70
Depth of the ulcer (mm):					
V1_Depth	3.8	4.0	3.0	5.0	1.42
V2_Depth	2.6	2.0	2.0	4.0	1.50
V3_Depth	1.4	1.0	0.0	3.0	1.31
V4_Depth	0.3	0.0	0.0	0.0	0.67
Area of the ulcer(mm^2):					
V1_Area	481.0	368.0	208.0	806.0	361.22
V2_Area	370.8	324.0	135.0	660.0	276.94
V3_Area	146.8	99.0	0.0	256.0	153.97
V4_Area	29.0	0.0	0.0	0.0	66.90

Comments:

I. Mean age of the patients was 51.1 years with a SD of 13.99 years and median age was 49 years.

II. Mean depth of the ulcer of patients was 3.8 mm at the beginning of the study which decreased subsequently with every visit and finally reached to 0.3 mm at the 4th or final visit.

III. Mean surface area of the ulcer of patients at the beginning of the study was 481.0 mm^2 with a SD of 361.22 mm^2 which was decreased to 29 mm^2 at the end of the study.

Table-5: Repeated Measure ANOVA
Comparison of changes of ulcer depth over time –Group PTB with BWI (n=27)

Friedman's ANOVA	Friedman statistic value 78.000 p value < 0.001	
Dunn's Multiple Comparison Test	**Difference in rank sum**	**P value**
V1_Area vs V2_Area	27.000	< 0.05
V1_Area vs V3_Area	57.000	< 0.001
V1_Area vs V4_Area	76.000	< 0.001
V2_Area vs V3_Area	30.000	< 0.01
V2_Area vs V4_Area	49.000	< 0.001
V3_Area vs V4_Area	19.000	Ns

Comments: The mean area of ulcer decreased with every visit when compared to the previous one. Friedman's ANOVA with multiple comparisons shows statistically significant reduction in the mean ulcer area when compared with any previous visit except when compared between V3 and V4.

Table-7: Ulcer healing at third visit at 3rd. week (n=27)

STAGE OF HEALING	NUMBER	TOTAL(%)
Healed	8	29.63
Non healed	19	70.37
TOTAL	27	100%

Comments: Around one third of ulcer patients (29.63%) found to have cured completely at third visit.

Table-8: Final outcome of ulcer at 6th. week between groups (n=27)

STAGE OF HEALING	NUMBER	TOTAL(%)
Healed	21	77.78
Non healed	6	22.22
TOTAL	27	100%

Comments: Around 77.78% patients of PTB group found to have cured completely at the end of the study. The percentage of cast failure 22.22%, at the end of six week.

DISCUSSION:

Neuropathic plantar foot ulceration mostly due to the consequence of diabetes and Hansen's disease is one of the regularly treated condition in the department of Physical Medicine and Rehabilitation. In our parallel group randomized control study, conducted at the department of Physical Medicine and Rehabilitation at IPGME&R, over the period of eighteen months, we look for the efficacy of PTB casting with Bohler's walking iron as a treatment modality in patients with neuropathic plantar foot ulcer affecting unilateral foot. After getting ethical committee clearance, we included total 27 patients. Fortunately we did not lost any of them; all the patients completed the study and attended all follow up visits. In our study we noticed mostly male (59.26%) in their middle age (mean age - 51 years) were affected which is also corroborating with the study conducted by Mark Myerson et al [3] showing a male predominance with mean age group of 4th and 5th decade. However the other study reported by Ezio Fagila et al [4] showed the most of the patients are in their 6th decade with male dominance. Off-loading is an etiologic therapy of neuropathic plantar foot ulcers. It has been proven by literature that when correctly applied it not only interrupt the pathogenic chain which produces the ulceration but also to induce modifications in the histology of the ulcer, shifting it from a chronic inflammatory state to a much more evolutive condition. Most of the study done by Mark Myerson et al [3] , Ezio Fagila et al [4] , Brenner MA [5] etc reported that most of the ulcer their study group were diabetic patients. Interestingly we got nearly 77.78% healing in period of 6 weeks. In the study by Ezio Fagila et al [4] found 73.9% healing rate in TCC group. Sinacore DR[6] noted healing in 82% of 33 ulcers after an average of forty four days in total contact cast. Ira A Katz, et al.[7] reported a 73% rate of healing in 41 patients studied at 12 weeks. Whereas Bowker JH et al, [8] found healing in 100% of seven patients who wore a total contact cast for an average of six weeks. The combined results of these studies yields an average rate of successful healing of 75.5% after an average of 38.7 days in the cast. In a study by Priyanka Saikia et.al.[9] Thirty consecutive diabetic patients with plantar ulcers (forefoot/mid-foot/hindfoot; Wagner grade 2 or 3; with palpable peripheral pulses) were enrolled and used the Bohler iron plaster cast (BIPC), Subjects were evaluated twice, i.e., before application of the cast and 1 month after. This pilot study results showed that BIPC significantly improves ulcer healing. In another study done by J. Berwin, et.al.[10] using Beagle Böhler Walker, a non-invasive frame that fits onto a standard below knee plaster cast, designed to achieve a reduction in force across the foot and ankle and objective was to measure loading forces through the foot to examine how different types of casts affect load distribution. They aimed to determine whether the Beagle Böhler Walker is as effective or better, at reducing load distribution during full weightbearing. They applied force sensors to the 1st and 5th metatarsal heads and the plantar surface of the calcaneum of 14 healthy volunteers. Force measurements were taken without a cast applied and then with a Sarmiento Cast, a below knee cast, and a below knee cast with Böhler Walker fitted. Compared to a standard below knee cast, the Böhler Walker reduced the mean peak force through the first metatarsal head by 58.9% ($p < .0001$); 73.1% through the fifth metatarsal head ($p < .0001$); and by 32.2% ($p < .0001$) through the calcaneum. The Sarmiento cast demonstrated a mean percentage reduction in peak force of 8.6% ($P = .39$) and 4.4% ($P = .87$) through the 1st and 5th metatarsal heads respectively, but increased the mean peak force by 5.9% ($P = .54$) through the calcaneum. They have concluded that using a Böhler Walke frame applied to a below knee cast significantly reduces load bearing through the foot compared to a Sarmiento cast or a standard below knee cast. This study explains the biomechanical aspect of significant outcome of our study. As per Study by Stack, 2017, **Böhler's iron with casts for offloading:** the use of a Böhler's iron in conjunction with a cast will provide axial offloading[11].

The results of our study indicate that pressure off-loading using the PTB casting with Bohler's walking iron is effective in the treatment of neuropathic plantar foot ulcer.

LIMITATION

1. No control group was taken.
2. Sample size was small in each group.
3. Comparison of our result of improvement due to PTB casting with Bohler's walking iron with standard literature was difficult due to paucity of previous evidences.

CONCLUSION

1. In our study, mostly male of 3rd and 4th decade were affected with neuropathic plantarfoot ulcer.
2. There is significant reduction of ulcer depth
3. Significant reduction of ulcer area at the initial visits up to 3 weeks.
4. Our study failed to conclude about the improvement pattern of different grades of the ulcer according to Wagner staging due to small sample size.
5. Overall healing rate of ulcer was very good. Although approximately 30% of the ulcer healed quite well after the period of 3 weeks of treatment but majority of the ulcer (77.8%) healedat the end of the study i.e. 6 th. week.
6. As per our study, PTB casting with Bohler's walking iron were effective not only for reduction of ulcer dimension but also effective in respect to final outcome and healing.

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