Predicting & Preventing Diabetic Ulcerations Utilizing Computerized Pressure Gait Analysis

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Introduction

It has been demonstrated in clinical practice and the literature that diabetics are prone to dermal ulcerations. It is believed that a foot deformity with elevated plantar pressures plays a significant role in the relationship between foot deformity and plantar injury.
Introduction

- There are a number of risk factors for the development of diabetic ulceration in diabetics. For example, peripheral neuropathy, peripheral vascular disease, limited joint mobility, and high plantar pressure and abnormal pressure can act as precursors to the formation of diabetic pressure ulcers. 1,3,5.
Introduction

- Predicting the location of these potential diabetic ulcerations can have important implications in the prevention of their formation, and potential complications.
Peak plantar pressure (PPP) has been used as a measure of trauma to the plantar aspect of the foot, and one of the contributing factors in the development of skin breakdown in individuals with diabetes and diabetic peripheral neuropathy. The level of pressure, repetitive pressure as well as the duration are mechanical factors that also contribute to skin breakdown. 6.
Introduction

Contact pressure on the plantar aspect of the foot generates forces in the subsurface tissue, and causes it to deform. The “breakdown” develops when the contact pressure load leads to a permanent distortion of the tissue and to the formation of localized tissue damage. 10.
Purpose

The purpose of this presentation is demonstrate the use of a mat pressure system as a predictor for increased plantar pressure areas and potential risk sites for ulceration in the diabetic foot. Utilizing a computerized gait and pressure analysis mat system as a preventative tool and for prescribing proper diabetic shoe gear and insole/orthotics can be advantageous for the foot or diabetic specialist.
Materials and Methods

Several systems for measuring plantar pressure in the foot are currently available. Among those are the E-med, Pedobarographs, F-Scan/Mat-Scan*, and Piezoelectric insoles. For this clinical study, the Mat-Scan* was utilized to perform pressure analysis of the foot. Pressure sensors within the mat can detect increased foot pressure and whether this pressure is evenly distributed, or concentrated in certain anatomical areas of the foot.
Terms Related to Pathomechanics

Pathomechanics is a term associating pathologies that affect and perturb the normal mechanical/physical function of an organ, segment or joint.

Pathomechanics related to foot function and gait can be defined in 2 major categories:

- Physiological related disorders.
- Biomechanical related disorders.
Terms Related to Pathomechanics...

Examples of **physiological** related disorders include:
- Pressure sores, skin breakdown and/or ulcers such as in patients having diabetes and/or neuropathy.

Examples of **biomechanical** related disorders include:
- Physical dysfunctions of the segments and/or joints with related soreness and/or pain in the muscles, tendons, ligaments and/or bones.
Parameters to Analyze Physiological Related Disorders

Parameters to analyze physiological related disorders include:

- Peak Pressure within the area of concern (pressure sore, ulcer),

- Maximum (average) Pressure under the area of concern (pressure sore, ulcer), and

- Integral (Pressure-Time relationship) under the area of concern (pressure sore, ulcer).
What is Pressure?

It represents the force applied uniformly and perpendicular onto a surface. It is also referred to as a measure of force exerted per unit area.
What is Integral?

Integral refers to the relation between the amount of pressure and the amount of time that the pressure is acting, in effect or applied.

It is also referred to as the capacity of work (loading impact).
Assess for Reduction in Peak Pressure within the Area of Concern

Before treatment
Peak Pressure (black box) = 61 PSI

After treatment
Peak Pressure (black box) = 42 PSI

This confirms a positive reduction in the Peak Pressure within the ulcer.
Assess for Reduction in the Integral (Pressure-Time relationship) Under the Area of Concern

Before treatment
Integral (green box) = 26.6 PSI*sec

After treatment
Integral (red box) = 9.9 PSI*sec

This confirms a positive reduction in the Integral (Pressure-Time relationship) under the ulcer area.
Biomechanical- Predicting Plantar Pressure
Predicting Peak Pressure
Peak Pressure

Peak Pressure versus Percent of Stance

Pressure versus Percent of Stance

Peak Pressure by Foot

Pressure by Foot
Force versus Percent of Stance:

Pressure Time Integral by Foot

Peak Pressure Gradient by Foot
Screening Results

- **Red** color profile under the forefoot indicates area of high pressure loading. The ulcer site is shown with the red rectangle.
- Patient with diabetic neuropathy.
Screening Results
Risk Factors for Diabetic Foot Ulceration-Intrinsic

- Peripheral sensory neuropathy
  - Sensorimotor
  - Autonomic
- Previous ulceration/amputation
- Poor glycemic control
- Duration of diabetes
- Vascular disease
  - Macrovascular
  - Microvascular
- Immunopathy/susceptibility to infection
- Structural foot deformity
- Biomechanical dysfunction
- Limited joint mobility
- Advanced age
- Blindness/partial sight
- Callus
CharM01. No Orthotic. Patient is experiencing pain and ulceration under his 2nd MT on the left foot (56.8 PSI). Graphs on Force vs. Time curves (red-left foot/ green-right foot) indicate non-symmetrical heal strike vs. forefoot left (red curve) and non-symmetrical left vs. right force curves. The blue curve under the left forefoot illustrates an increase in force/time on that foot during propulsive phase of gait. The yellow and blue curves intersect early in the foot strike. The foot moves early into the active propulsive phase. The result is high peak pressure.
Symmetry of Pressure
CharM01. TAM pinpoints gait asymmetries by phase. Active Propulsive at 8% of gait. It should be between 19-21% of gait. Peak Pressure 2nd MT Left at 57 PSI. This is the cause of the ulceration and MT pain. Hallux well below average % stance. The resolution of the sensor allows the clinician to accurately place the boxes under the MT sites.
Symmetry of Pressure
Prevention and Screening

- **Barefoot Screenings** with computerized mat provide helpful data for assessment and treatment. Parameters for analysis include:
  - Peak Pressures
  - Timing
  - Center of Force Trajectory
  - Contact Area
Pressure Mapping: EPOD
Cycle of Care

- Document
- Educate
- Off Load
- Prevent
“Man cannot discover new oceans unless he has the courage to lose sight of the shore”

-Andre Gide
Preventing Wounds
Case History
Case History
Case History
Case History
Case History
Case History
Case History
Conclusions

- New technology has allowed the practitioner to utilize a computerized mat pressure sensitive apparatus. As a screening device for diabetic neuropathic feet, this scan can determine where the high pressure areas “hot spots” of the feet are located. In the case presentations, specific areas of peak plantar pressure were determined, with subsequent shoe and accommodative insole intervention to reduce plantar pressure and prevent ulceration or recurrence.
Off-load: Orthotic Prescription

Based on the MatScan data we just reviewed, the desired treatment outcome is to reduce the amount and time of loading at the forefoot (especially under the ulcer), and to support the medial arch by redistributing pressure to the midfoot area and help off-load the forefoot.
Accommodative Orthotics
Comprehensive Off-Loading

- Debridement
- Acute pressure relief
- Accommodation
- Surgical prophylaxis
References

1. Albert, SF Christensen LC, Diabetic Foot Pressure Studies -comparison study of patient-selected shoes versus clinician-selected shoes; The Lower Extremity Vol 1 No 1 1994, Pages 21-27.


* F-Scan/Mat-Scan (Tekscan, Boston, Mass)
The Desert Foot
The 6th Annual High Risk Diabetic Foot Conference
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