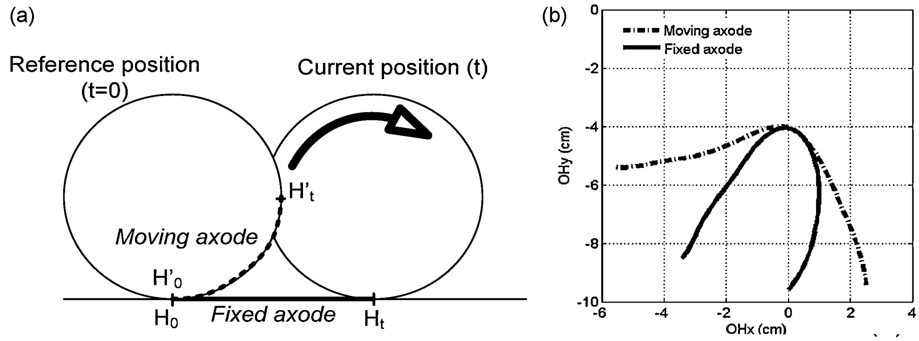

Fig. 1. (a) Cylinder rolling over a plane. As the cylinder moves, its IHA describes the fixed axode that coincides with the plane. If we assume the cylinder fixed and the plane rolling, then we obtain the moving axode that matches with the cylinder surface. (b) Application of this model to neck flexion–extension. The movement of the head relative to the thorax is the same as the one of the moving axode rolling without sliding on the fixed axode. The radiography is only for orientative purposes, to show an approximate scale.

an intuitive representation of joint movement. Nevertheless, a simple interpretation of the IHA can be made for planar motions with one *functional* degree of freedom (fDOF) [4–6]. Then the motion is equivalent to the rolling without sliding between two surfaces (the axodes). An experimental application to the neck joint is performed to validate the technique.

Materials and methods

The average IHA path was computed from various movement repetitions as described in [6]. From this IHA path, which can be interpreted as a geometric characteristic of the joint, the joint is modelled by two surfaces (the axodes) that roll without sliding on each other, reproducing the same movement performed by the joint. The first surface is fixed to the proximal segment and corresponds to the surface described by the IHA throughout the movement. The second one corresponds to the IHA measured on a reference fixed to the distal segment. Fig. 1a depicts an example of this model: a cylinder rolling over a plane. The IHA path coincides with the plane or with the cylinder surface depending on what segment is considered as fixed. Thus, the IHA allows estimating these surfaces from merely kinematic data. We applied the method to the neck flexion–extension of one subject measured with stereophotogrammetry.

Results and discussion

Fig. 1b depicts the two surfaces that constitute the rolling pair associated to the analyzed movement. This motion can be exactly represented as the one performed by the moving axode (doted line) when it rolls on the fixed axode (solid line). The tops of these surfaces correspond to the neutral position. The agreement between the experimental data and the kinematics predicted by the model are good both for position variables (R = 0.9997) and for velocities (R = 0.998). Note that the IHA is not a fixed axis, but describes a path with a range of more than 5 cm in vertical direction. This result agrees with those obtained in [1,3]. The condition of one fDOF was tested for the analyzed motion [5] and can be accepted for many simple movements that are used in diagnostic tests, as implicitly assumed in several studies that represent the entire motion with only one joint variable.

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O75

Correlation between plantar pressure and Oxford Foot Model kinematics in clubfoot

Jennifer McCahill [1,*], Julie Stebbins [1], Claudia Giacomozzi [2], Tim Theologis [1]

[1] *Oxford Gait Laboratory, Nuffield Orthopaedic Centre, Oxford, United Kingdom*
[2] *Istituto Superiore di Sanita, Rome, Italy*

Summary

Plantar pressure does not always correlate to foot position. In post surgical clubfoot the hindfoot position directly correlates with hindfoot loading and the forefoot position inversely correlates with hindfoot loading.

Conclusions

Correlating multi-dimensional foot kinematics with plantar pressure measurements enables advanced understanding of dynamic foot deformity and its effects on forces under the foot. It provides information on primary and secondary deformities and guides clinical management.

Introduction

Plantar pressure measurements and multi-segment foot model kinematics are used in clinical gait analysis to assist in the objective measurement of dynamic foot deformity. The aim of this study was to correlate the findings of pressure measurements with Oxford Foot Model (OFM) kinematics [1] to provide a comprehensive assessment of foot deformity.

Patients/materials and methods

11 children with idiopathic clubfoot treated at a young age with a postero-medial release were assessed (6 male, 5 female, age 10.5 ± 3.3 years) using lower limb kinematics, OFM [1] kinematics and plantar pressure. Kinematic data were collected with a 12 camera Vicon 612 system (Oxford, UK). Plantar pressure data were collected with a prototype, piezo-resistive pressure plate (Istituto Superiore di Sanita, Rome, Italy) with a spatial resolution of 4 sensors/mm^2 [2]. The OFM markers were superimposed onto the pressure footprint during mid-stance. The co-ordinates of each marker were then projected vertically onto the footprint. This allowed the foot to be divided into five sub-sections on the basis of anatomical landmarks, and to correlate pressure findings with the output from the OFM. Peak force from each subdivision was correlated with clinically relevant variables from the OFM. For the purpose of this study, only the affected limb was analyzed; for children with bilateral clubfoot, the right leg was analyzed.

Results

A significant inverse correlation (−0.52) was found between forefoot supination (in relation to the hindfoot) and the ratio of lateral/medial distribution of force at the hindfoot. An inverse correlation (−0.48) was also found between increased forefoot dorsiflexion (in relation to the tibia) and reduced forefoot force as expected. A low correlation (0.35) was found between hindfoot varus and the ratio of lateral/medial hindfoot loading and between hindfoot varus and midfoot loading (0.26). Using independent *t*-tests ($p < 0.05$) compared to healthy controls, the force in the midfoot ($p < 0.00$) and lateral forefoot ($p = 0.04$) were increased. The force in the medial forefoot was reduced ($p < 0.00$). Comparing the OFM kinematics to healthy controls showed a significant reduction in dorsiflexion at the hindfoot ($p = 0.01$), at the forefoot ($p < 0.00$), and of the forefoot in relation to the tibia ($p < 0.00$). Maximum dorsiflexion in swing was also significant at the forefoot ($p = 0.01$) and of the forefoot in relation to the tibia ($p = 0.03$).

Discussion

Forefoot pronation was found to be directly linked with increased lateral loading of the hindfoot which is not necessarily intuitive. This suggests a varus hindfoot is coupled with relative forefoot pronation even though the overall position of the foot seems supinated. The force at the midfoot was significantly higher than the healthy population regardless of whether the hindfoot was in a varus or valgus position. If the midfoot was sectioned into medial and lateral components it would likely show a stronger correlation.

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O76

Cervical spine motion analysis in asymptomatic children: Evaluation of 4 cervical collars

Ayman Assi [1,*], Paul Yazbeck [2], Abyr Massaad [1], Wafa Skalli [3], Ismat Ghanem [2]

[1] *SESOBEL, Gait and Motion analysis lab, Beirut, Lebanon*
[2] *Hotel Dieu de France Hospital, Beirut, Lebanon*
[3] *Laboratoire de Biomecanique CNRS UMR 8005, Arts et Metiers Paris-Tech, Paris, France*

Summary

This study evaluates the efficiency of 4 cervical collars in decreasing neck motion in asymptomatic children. The decrease in Range of Motion (ROM) was calculated for each collar relatively to the ROM obtained without collar during flexion/extension, lateral bending and axial rotation. A repeatability study was performed and coupled movements of cervical spine were quantified.

Conclusions

The Necloc collar showed a high level of decrease in ROM in flexion/extension. However, the Miami Jr cervical collar had the largest decrease in ROM in the three planes. Coupled movements were highest during lateral bending.

Introduction

The cervical part of the spine is the most mobile segment, and is of a particular importance in cases of trauma because of the high risk of osteo-ligament injury. Several cervical collars are used in adults with varying degrees of efficiency. The cervical immobilization in children presents a problem of availability of suitable collars and has not yet been evaluated in the literature.

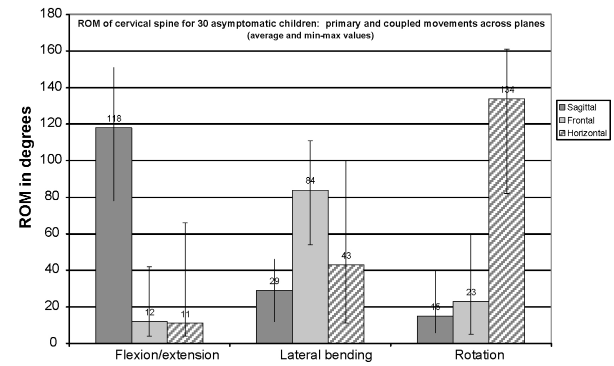

Fig. 1. ROM of cervical spine for 30 asymptomatic: primary and couple movements across planes (average and min-max values).

Patients/materials and methods

30 asymptomatic children aged between 6 and 12 years participated to the study, mean age 9 years (SD = 2), mean height 136 cm (SD = 12.5). Four mean sizes of cervical collars (Philadelphia, Miami Jr, Necloc and the conventional hard collar), designed for such population, were tested by each subject. 3D-motion analysis of neck motion was performed with and without cervical collar using the Plug in Gait model of Vicon® system. Subjects were asked to perform flexion/extension of the neck, and right and left lateral bending and rotation. The Decrease of motion (in %) was calculated for each collar during each movement relatively to the ROM obtained without collar. 13 subjects have done the exam twice (with an interval of one week) to study the repeatability of the protocol. Coupled movements in all planes were quantified during flexion/extension, lateral bending and axial rotation.

Results

Significant differences were found between collars ROM across movements ($p < 0.05$). Maximum of decrease in ROM was found for Necloc (77%) during flexion/extension. The hard collar had minimum decrease in ROM (66%) relatively to the other collars in flexion/extension. Philadelphia had minimum decrease in ROM in the frontal plane (47% v/s 63% for other collars). Miami Jr and Necloc had the largest decrease in ROM during rotation (79% v/s 67% and 65% for other collars). No significant differences were found between sessions for subjects who performed the exam twice ($p > 0.05$). However, 2SD of inter-session differences were 19° for flexion/extension, 10° for lateral bending and 17° for axial rotation. Significant coupled movements were found ($p < 0.05$) especially during lateral bending (see Fig. 1).

Discussion

This study showed that the Miami Jr had the larger decrease in ROM of cervical spine during all movements: flexion/extension, lateral bending and axial rotation. The high range of inter-session variability was mostly due to the variability intra-subject of maximum possible movement, especially in extension.

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