Walking **Pain Free**

New insoles designed with the ANSYS mechanical suite relieve pain from foot disease.

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The human foot does more than simply enable mobility. Feet are an important part of the body because they bear weight, absorb shock and stabilize body structure, but they usually get little of our attention. When foot disease appears and pressure and stress exceed a given limit, pain occurs — making a person suddenly aware of just how critical a function the feet provide. For people with diabetes, subject to poor circulation and neuropathy, even ordinary foot problems can get worse and lead to serious complications.

One research project designed to benefit such patients involves developing insoles that will prevent pressure sores on the deep tissues inside the plantar surface of the foot. A team at the Institute of Medical Engineering at Yonsei University in Korea is finding new ways to gather information on the mechanical response of the foot to various insole designs. They are utilizing finite element analysis (FEA) software from ANSYS, Inc. to design new patient-specific insoles that reduce both pressure during ambulation and stress within the feet, ultimately relieving pain. The team selected the ANSYS mechanical suite because of its reliability and flexibility for handling complex and irregular geometries. Furthermore, its nonlinear, hyper-elastic models and advanced contact conditions provide a realistic alternative to experimental approaches for gait analysis.

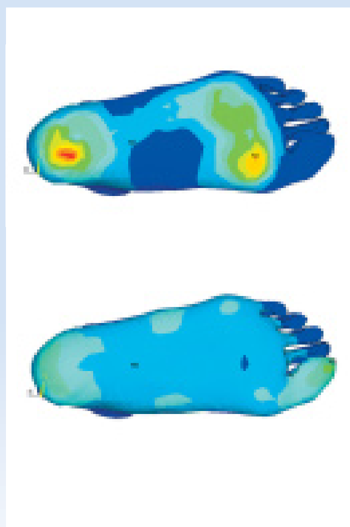
Using the ANSYS technology, the researchers first created a three-dimensional model using computerized tomography (CT) images obtained from the right foot of a subject with hallus valgus, commonly called a bunion. Commercial software, CANTIBio™ (CANTIBio, Inc., Korea) and meshing software were used to fine tune the contours of the foot.

Three geometries representing three primary states (initial contact, mid-stance and toe-off) during ambulation then were created. The simulation models incorporated two insole designs: one flat and one contoured to contact the entire bottom of the foot. Each design was analyzed at various values of elastic modulus (0.3 MPa, 1.0 MPa and 1 GPa) in order to represent a variation in insole firmness and identify which more effectively redistributed von Mises stresses on the plantar, or bottom, surface of the foot during standing.

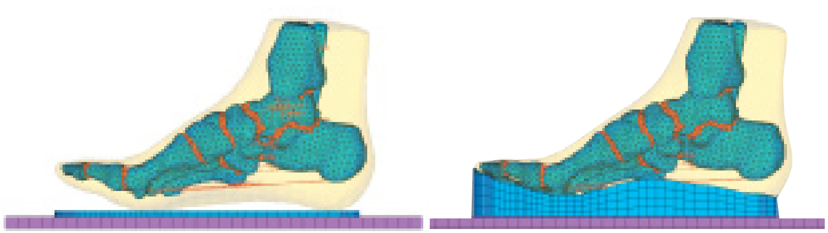
During ambulation, ANSYS software showed that high pressures first appear on the plantar surface region overlying the heel bone for the initial contact state, progresses through the middle of the foot for the mid-stance state, and finally, for the final toe-off state, is concentrated in the vicinity of the metatarsal head bone at the front of the foot. These results are in agreement with those obtained from a foot scan system used in experimental gait analysis.

The results found that stresses on the plantar surface are significantly lower with the total contact insole compared with those of the flat insole; stresses also are dependent on the insole elastic modulus. This confirms that customized design of an insole for patients with foot disease may be necessary, and the solution should include biomechanical and clinical points of view. ■

During ambulation (top to bottom), the highest pressure progressively shifts from the plantar region under the heel bone forward to the metatarsal head bone.



Von Mises stress distributions on the plantar surface of the foot using the flat (top) and total contact insoles (bottom)



Two insoles, one flat (left) and one shaped to contact the entire sole of the foot (right), were compared in this analysis to understand the impact of the geometry on foot pain.