Computerized Motion Diagnostic Imaging

Number: 0432

Policy

*Please see amendment for Pennsylvania Medicaid at the end of this CPB.*

Aetna considers the use of computerized motion diagnostic imaging experimental and investigational for evaluation of the spine or any other indications because there is a lack of evidence that this imaging alters clinical management and improves clinical outcomes.

Aetna considers vertebral motion analysis for evaluation of the spine or any other indications experimental and investigational because of insufficient evidence of its effectiveness.

Aetna considers the DARI scan (functional motion analysis) experimental and investigational because of a lack of evidence of its effectiveness.

See also

CPB 0263 - Gait Analysis and Electrodynogram

and CPB 0294 - Pedobarography.
Computerized Motion Diagnostic Imaging (CMDI) Systems (Motion Diagnostics Laboratories, Hauppauge, NY) employ a dual-inclinometer and/or a long-arm goniometer and computer software to track range of motion and can allegedly estimate the percentage of impairment of the spine. However, there is a lack of evidence in the published peer-reviewed medical literature to support the usefulness of these devices in improving clinical outcomes.

Piche and colleagues (2007) developed a measurement method that could be implemented in chiropractic for the evaluation of angular and translational intervertebral motion of the cervical spine. Flexion-extension radiographs were digitized with a scanner at a ratio of 1:1 and imported into a software, allowing segmental motion measurements. The measurements were obtained by selecting the most antero-inferior point and the most postero-inferior point of a vertebral body (anterior and posterior arch, respectively, for C1), with the origin of the reference frame set at the most postero-inferior point of the vertebral body below. The same procedure was performed for both the flexion and extension radiographs, and the coordinates of the 2 points were used to calculate the angular movement and the translation between the 2 vertebrae. These researchers reported that this method provided a measure of intervertebral angular and translational movement. It uses a different reference frame for each joint instead of the same reference frame for all joints and thus provides a measure of motion in the plane of each articulation. The calculated values obtained are comparable to other studies on intervertebral motion and support further development to validate the method. The authors concluded that the present study proposes a computerized procedure to evaluate intervertebral motion of the cervical spine. This procedure needs to be validated with a reliability study but could provide a valuable tool for doctors of chiropractic and further spinal research.

Harrison et al (2008) examined the accuracy in measuring the pelvic orientations of a phantom model (a mannequin was fixed on a rotating platform) using the PosturePrint method. For a set of 3 photographs (left lateral, anterior to posterior, right lateral) of each position, the mannequin pelvis was placed in 68 different postures on a stand, 61 cm from a wall, in front of a digital camera. The camera was at 83.8 cm in height and at 3.35 m from a calibrated wall grid. Mannequin postures were in 5 degrees of freedom: lateral translation (Tx), lateral flexion (Rz), axial rotation (Ry), flexion-extension (Rx), and anterior-posterior translation (Tz). Average errors were the differences of the positioned postures to the PosturePrint computed values. Mean and SD of computational errors for rotation displacements
were Rx = 0.5 degrees +/- 0.8 degrees, Ry = 1.3 degrees +/- 0.8 degrees, and Rz = 0.5 degrees +/- 0.3 degrees, and for translation, Tz = 1.2 +/- 0.6 mm and Tx = 0.9 +/- 0.5 mm. The authors concluded that the PosturePrint system allowed for accurate postural measurement of rotations and translations of a mannequin pelvis. The next step in evaluation of this product would be a reliability study on human subjects.

MacDonald and colleagues (2010) stated that previous research has quantified cervical spine motion with conventional measurement techniques (e.g., cadaveric studies, motion capture systems, and fluoroscopy), but these techniques were not designed to accurately measure three-dimensional (3-D) dynamic cervical spine motion under in-vivo conditions. The purposes of this study were to characterize the accuracy of model-based tracking for measuring 3-D dynamic cervical spine kinematics and to demonstrate its in-vivo application. The accuracy of model-based tracking for measuring cervical spine motion was determined in an in-vitro experiment. Tantalum beads were implanted into the vertebrae of an ovine specimen, and biplane X-ray images were acquired as the specimen’s neck was manually moved through neck extension and axial neck rotation. The 3-D position and orientation of each cervical vertebra were determined from the biplane X-ray images using model-based tracking. For comparison, the position and orientation of each vertebra were also determined by tracking the position of the implanted beads with dynamic radio-stereometric analysis. To demonstrate in-vivo application of this technique, biplane X-ray images were acquired as a human subject performed 2 motion tasks: neck extension and axial neck rotation. The positions and orientations of each cervical vertebra were determined with model-based tracking. Cervical spine motion was reported with standard kinematic descriptions of translation and rotation. The in-vitro validation demonstrated that model-based tracking is accurate to within +/- 0.6 mm and +/- 0.6 degrees for measuring cervical spine motion. For the in-vivo application, there were significant rotations about all 3 anatomical axes for both the neck extension and axial neck rotation motion tasks. The authors concluded that model-based tracking is an accurate technique for measuring in-vivo, 3-D, dynamic cervical spine motion. They noted that these preliminary data acquired using this technique are in agreement with previous studies. It is anticipated that this experimental approach will enhance the understanding of cervical spine motion under normal and pathologic conditions.

Mieritz et al (2012) reviewed the literature on reproducibility (reliability and/or measurement error) of 3-D regional lumbar motion measurement systems.
Electronic searches were performed in PubMed, Cumulative Index of the Nursing and Allied Health Literature, Embase, and Mantis databases. To be included, original studies had to report on the reproducibility of a 3-D computerized regional lumbar spinal motion analysis system in human subjects. A detailed checklist was developed based on guidelines for reporting reliability and agreement studies, the standards for reporting of diagnostic accuracy, and quality assessment of diagnostic accuracy studies and used for data extraction and quality assessment. The checklist consisted of descriptive items divided into 4 domains: (i) study population, (ii) testing circumstances, (iii) equipment, and (iv) data analysis and presentation. The descriptive items were used as foundation for the quality assessment reflecting the reporting level of the included articles. A total of 15 articles were included in this study. These researchers found incomplete reporting in 1 or more domains in all articles. A varying amount of measurement error was reported in 8 of the 15 articles. Because of incomplete reporting, these reliability and measurement error estimates are difficult to interpret. The authors concluded that the current literature on the reliability and measurement error of measures created by regional 3-D spinal instruments contained uncertainties especially in relevant clinical populations. There is uncertainty with respect to the degree that repeated measurements by 3-D regional spinal motion instruments are reproducible. However, limited to the studies where reliability estimates were provided, most instruments used under standardized conditions may be considered reliable enough to be used for research purposes on the group level, but it is uncertain if they can be used on the individual patient level.

Vertebral Motion Analysis:

O'Sullivan et al (2012) stated that a novel, minimally invasive posture monitor that can monitor lumbar postures outside the laboratory has demonstrated excellent reliability, as well as concurrent validity compared to a surface marker-based motion analysis system. However, it is unclear if this device reflects underlying vertebral motion. A total of 12 participants performed full range sagittal plane lumbo-pelvic movements during sitting and standing. Their posture was measured simultaneously using both this device (BodyGuard) and digital videofluoroscopy. Strong correlations were observed between the 2 methods (all r (s) > 0.88). Similarly, the coefficients of determination were high (all r (2) > 0.78). The maximum mean difference between the measures was located in the mid-range of motion and was approximately 3.4° in sitting and 3.9° in standing. The authors concluded that the
BodyGuard appears to be a valid method for analyzing vertebral motion in the sagittal plane and is a promising tool for long-term monitoring of spinal postures in laboratory and clinical settings in people with low back pain (LBP).

Bifulco et al (2012) stated that in-vivo analysis of intervertebral kinematics provides useful information about spinal disorders and performance of disk prostheses. Diagnosis of intervertebral instability is based on measurement of abnormal range of segmental motion in sagittal plane through functional flexion-extension radiography; however, this concise measure does not take into account the progression of segmental motion in between flexion and extension extremes. Fluoroscopy can support analysis of intervertebral kinematics during patient's motion with an acceptable X-ray dose. A spline-based method designed for a continuous-time description of intervertebral motion extracted by videofluoroscopy is proposed. Fluoroscopic sagittal sequences of lumbar spine were processed by an automated method based on template matching to track vertebrae. A smoothing spline interpolation of the estimated intervertebral kinematic data was performed and a continuous-time description of segmental rotation and translation was obtained; the smoothing parameter was chosen both to preserve motion and to reduce noise. Concise measurements were extracted by the continuous-time kinematics and compared with standard clinical measurements of intervertebral sagittal rotation and translation. The trajectory of instantaneous center of rotation, never presented before for in-vivo spinal segments, was provided and compared with standard measurements of the finite center of rotation. Results showed a good agreement with standard clinical measurements: on average, absolute differences resulted 0.74 degree for sagittal rotation, 0.59 mm for translation and 1.02 mm for the x- and y-position of center of rotation. The authors concluded that the proposed method offers an effective technique for the continuous-time description of intervertebral motion, maintaining standard clinical measurements for diagnosis of lumbar instability. This appears to be a feasibility study; its validity in the clinical setting needs to be ascertained in well-designed studies.

Tojima et al (2013) studied the repeatability and reliability of a novel 3-D motion analysis method for measuring the lumbar spine range of motion (ROM). They established a novel set of marker positions for 3-D motion analysis (VICON system) to determine lumbar spine ROM (LROM) and lumbar motion precisely; they compared the repeatability and reliability of VICON system with those of an electrogoniometer. The VICON system and electrogoniometer measured LROM and lumbar motion in 7 healthy males during 7 days. Differences between both
systems were analyzed using Bland-Altman plots. Repeatability and reliability of the LROM measurements was assessed using coefficients of multiple correlations and intra-class correlation coefficients, respectively. Standard error of measurement was calculated to quantify the systematic error in LROM measurements. The mean maximum LROM values using the VICON system/electrogoniometer were 42°/52° for flexion, 17°/24° for extension, 16°/16° for lateral bending, and 8°/2° for axial rotation, respectively. Between the VICON system and the electrogoniometer, Bland-Altman plots revealed no discrepancies in LROM values except for flexion. Coefficients of multiple correlations for LROM showed excellent repeatability. LROM measurements with VICON system showed excellent reliability for flexion and extension and fair-to-good reliability for other motions. LROM measurements with the electrogoniometer showed excellent reliability for flexion and fair-to-good reliability for other motions. Except for axial rotation, maximum intra-class correlation coefficients using the VICON system were more reliable than the electrogoniometer for measuring lumbar motion. The authors concluded that the VICON system with their novel marker set allowed practical and reliable longitudinal assessment of dynamic LROM. This was a repeatability and reliability study using healthy subjects (n = 7); these preliminary findings need to be validated by well-designed studies in patients with LBP.

The Work Loss Data Institute’s guideline on “Low back -- lumbar & thoracic (acute & chronic)” (2013) recommended fluoroscopy for epidural steroid injections (diagnostic and therapeutic). It does not recommend videofluoroscopy (for ROM).

Moreover, the American College of Occupational and Environmental Medicine (ACOEM)’s occupational medicine practice guideline on “The Low back disorders” (2011) stated that following:

- Fluoroscopy for evaluating acute, subacute, or chronic LBP -- Not Recommended, Insufficient Evidence (I)
- Videofluoroscopy for the assessment of acute, subacute, or chronic LBP -- Not Recommended, Insufficient Evidence (I)

Furthermore, an UpToDate review on “Diagnostic testing for low back pain” (Staiger et al, 2015) does not mention videofluoroscopy and vertebral motion analysis as management tools.
In a comparative study, Yeager et al (2014) determined the repeatability and reproducibility of sagittal lumbar intervertebral measurements using a new system for the evaluation of lumbar spine motion. A total of 205 intervertebral levels from 61 patients were retrospectively evaluated in this study. Outcome measures included coefficient of repeatability (CR), limits of agreement (LOA), intra-class correlation coefficient (ICC; type 3,1), and standard error of measurement. Intervertebral rotations and translations (IVR and IVT) were each measured twice by 3 physicians using the KineGraph vertebral motion analysis (VMA) system and twice by 3 different physicians using a digitized manual technique. Each observer evaluated all images independently. Intra- and inter-observer statistics were compiled based on the methods of Bland-Altman (CR, LOA) and Shrout-Fleiss (ICC, standard error of measurement). The VMA measurements demonstrated substantially more precision compared with the manual technique. Intra-observer measurements were the most reliable, with a CR of 1.53 (manual, 8.28) for IVR, and 2.20 (manual, 11.75) for IVT. The least reliable measurements were inter-observer IVR and IVT, with a CR of 2.15 (manual, 9.88) and 3.90 (manual, 12.43), respectively. The ICCs and standard error results followed the same pattern. The authors concluded that the VMA system markedly reduced variability of lumbar intervertebral measurements compared with a digitized manual analysis. Moreover, they noted that computer-assisted fluoroscopic imaging techniques demonstrated precision within the range of computer-assisted X-ray analysis techniques.

The main drawbacks of this study were: (i) the authors reported a small but statistically significant bias for inter-observer IVT in this study, (ii) the current study focused on reliability of overall lumbar measurements made from L1 to L2 to L5 to S1; however, differences between levels were not analyzed. Future analysis would be of value to compare the precision of independent levels, especially in post-operative patients where instrumentation has the potential to influence measurement error. This would be of particular importance when evaluating success of fusion constructs, as well as performance of motion preservation devices, and (iii) a significant advantage of digitized videofluoroscopy is the ability to capture motion characteristics of the spine throughout an entire ROM. Further research should focus on evaluating the reliability of intervertebral motion measurements throughout the entire image sequence. This will require the use of more complex statistical analyses than are currently in use for evaluating the repeatability and reproducibility of clinical measurement systems. These techniques must consider the time series of
intervertebral kinematic measurements as opposed to the discrete, end-range measurements presented here and elsewhere in the literature.

Mellor et al (2014) stated that quantitative fluoroscopy is an emerging technology for assessing continuous inter-vertebral motion in the lumbar spine, but information on radiation dose is not yet available. These investigators compared the radiation dose from quantitative fluoroscopy of the lumbar spine with lumbar spine radiographs, and identified opportunities for dose reduction in quantitative fluoroscopy. Internationally reported dose area product (DAP) and effective dose data for lumbar spine radiographs were compared with the same for quantitative fluoroscopy and with data from a local hospital for functional radiographs (weight bearing AP, lateral, and/or flexion and extension) \( n = 27 \). The effects of procedure time, age, weight, height and body mass index (BMI) on the fluoroscopy dose were determined by multiple linear regression using SPSS v19 software (IBM Corp., Armonck, NY). The effective dose (and therefore the estimated risk) for quantitative fluoroscopy is 0.561 mSv, which is lower than in most published data for lumbar spine radiography. The DAP for sagittal (flexion + extension) quantitative fluoroscopy is 3.94 Gy cm², which is lower than local data for 2-view (flexion and extension) functional radiographs (4.25 Gy cm²), and combined coronal and sagittal dose from quantitative fluoroscopy (6.13 Gy cm²) is lower than for 4-view functional radiography (7.34 Gy cm²). Conversely DAP for coronal and sagittal quantitative fluoroscopy combined (6.13 Gy cm²) is higher than that published for both lumbar AP or lateral radiographs, with the exception of Nordic countries combined data. The authors concluded that weight, procedure time and age were independently positively associated with total dose, and height (after adjusting for weight) was negatively associated, thus as height increased, the DAP decreased. This study did not address vertebral motion analysis.

Davis et al (2015) determined the performance measurements of sagittal lumbar intervertebral measurements using computer-assisted measurements of the lumbar spine using motion sequences from a video-fluoroscopic technique. A total of 2,239 intervertebral levels from 509 symptomatic patients, and 287 intervertebral levels from 73 asymptomatic participants were retrospectively evaluated. Outcome measures included specificity, sensitivity, negative predictive value (NPV), diagnostic accuracy, and prevalence between the 2 measurement techniques; measurements of CR, LOA, ICC (type 3,1), and standard error of measurement for both measurement techniques. Asymptomatic individuals and symptomatic patients were all evaluated using both the VMA system and fluoroscopic flexion extension.
static radiographs (FE). The analysis was compared to known thresholds of 15 % IVT (equivalent to 5.3 mm assuming a 35-mm vertebral body depth) and 25° IVR. The VMA measurements demonstrated greater specificity, % change in sensitivity, NPV, prevalence, and reliability compared with FE for radiographic evidence of instability. Specificity was 99.4 % and 99.1 % in the VMA compared to 98.3 % and 98.2 % in the FE for IVR and IVT, respectively. Sensitivity in this study was 41.2 % and 44.6 % greater in the VMA compared to the FE for IVR and IVT, respectively; NPV was 91 % and 88 % in the VMA compared to 62 % and 66 % in the FE for IVR and IVT, respectively. Prevalence was 12.3 % and 11.9 % for the VMA compared to 6.1 % and 5.4 % for the FE in IVR and IVT, respectively. Intra-observer IVR and IVT had a CR of 2.49 and 2.62, respectively; inter-observer IVR and IVT had a CR of 1.99 and 2.81, respectively. Intra-subject (test/retest) CR were 2.49 and 3.11 for IVR and IVT, respectively. The authors concluded that the VMA system showed greater measurement performance in the detection of radiographic instability compared with FE radiographs. These researchers stated that the VMA system has the potential to provide greater measurement performance by utilizing the combination of controlled motion and a semi-automated measurement technique to enhance the clinician’s ability to identify radiographic instability of the lumbar spine.

In a systematic review, Negrini et al (2016) examined the current state of affairs of non-gait-related optoelectronic trunk movement analysis; results have been analyzed from a clinical and a methodological perspective. Extensive research was performed on all papers published until December 31, 2015, dealing with trunk movement analysis assessed by optoelectronic systems, excluding those related to gait. The research was performed on January 14, 2016 on 3 databases: Scopus, Science Direct and PubMed. A reference search and expert consultation were also performed. Out of a total number of 8,431 papers, 45 were deemed relevant: they included 1,334 participants, 57.9 % healthy, with age range of 8 to 85 years. Few studies considered the whole trunk, and none focused on each vertebra independently: the trunk was almost always divided into 3 segments; 13 studies included 20 or more markers. Most of the papers focused mainly on the biomechanics of various movements; the lumbar area and low back pain were the most studied region and pathology respectively. The authors concluded that the findings of this study showed the relative scarcity of current literature focusing on trunk motion analysis. In clinical terms, results were sparse. The only quite well represented group of papers focused on the lumbar spine and pathologies, but the scarcity of individuals evaluated make the results questionable. They stated that the use of optoelectronic systems in the evaluation of spine movement is a growing
research area; however, no standard protocols have been developed so far. They stated that future research is needed to define a precise protocol in terms of number and position of markers along the spine and movements and tasks to be evaluated.

**DARI Scan (Functional Motion Analysis):**

DARI scan is a marker-less, motion capture technology platform that provides full-body biomechanical analysis and reporting in as little as 5 minutes. However, there is a lack of evidence of its effectiveness.

**CPT Codes / HCPCS Codes / ICD-10 Codes**

Information in the [brackets] below has been added for clarification purposes. Codes requiring a 7th character are represented by "+":

<table>
<thead>
<tr>
<th>Code</th>
<th>Code Description</th>
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<td><strong>CPT codes not covered for indications listed in the CPB:</strong></td>
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<tr>
<td></td>
<td>Vertebral motion analysis, DARI scan (functional motion analysis)-hyphen no specific code:</td>
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<tr>
<td>96000</td>
<td>Comprehensive computer-based motion analysis by video-taping and 3-D kinematics</td>
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<td>96001</td>
<td>with dynamic plantar pressure measurements during walking</td>
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<tr>
<td>96004</td>
<td>Review and interpretation by physician or other qualified health care professional of comprehensive computer-based motion analysis, dynamic plantar pressure measurements, dynamic surface electromyography during walking or other functional activities, and dynamic fine wire electromyography, with written report</td>
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<td></td>
<td><strong>ICD-10 codes not covered for indications listed in the CPB (not all-inclusive):</strong></td>
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<td>Segmental and somatic dysfunction</td>
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<tr>
<td>M99.20</td>
<td>Subluxation stenosis of neural canal</td>
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The above policy is based on the following references:


**Vertebral Motion Analysis/Videofluoroscopy:**


http://www.aetna.com/cpb/medical/data/400_499/0432.html
Gait analysis for planning surgery and therapy treatments for children with cerebral palsy will be considered on a case by case basis for the Pennsylvania Medical Assistance plan.