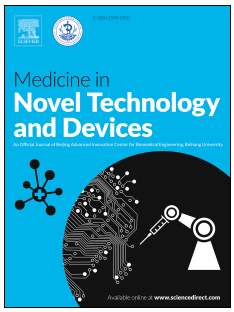

An Instrument for Methodological Quality Assessment of Single-Subject Finite Element Analysis Used in Computational Orthopaedics

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An Instrument for Methodological Quality Assessment of Single-Subject Finite Element Analysis Used in Computational Orthopaedics

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An Instrument for Methodological Quality Assessment of Subject-Specific Finite Element Analysis Used in Computational Orthopaedics

Abstract

The methodological quality of subject-specific finite element analysis papers depends on the rigor of the study design and detailed description of key elements, while assessment instruments are often confined to clinical trials or quasi-experiments. This study aims to present an instrument for methodological quality assessment of single-subject finite element analysis used in computational orthopaedics (MQSSFE). Based upon existing instruments and relevant review papers, a pilot version was developed consisting of 37 items with 6 domains, including study design and presentation of findings, subject recruitment, model reconstruction and configuration, boundary and loading conditions (simulation), model verification and validation, and model assumption and validity. We interviewed four experts in the field to assess the face validity and refined the instrument. The instrument was tested for interrater reliability among two assessors on nine finite element study papers. Also, the criterion validity was evaluated by comparing the similarity of the MQSSFE and the modified Down and Black instrument. The intraclass correlation coefficient was 0.965, while the MQSSFE was significantly moderately correlated with the modified Down and Black instruments ($r = 0.61$). We believed that MQSSFE was adequately appropriate, reliable, and valid for assessing the methodological quality for finite element studies used in computational orthopaedics. The instrument could facilitate quality assessment in the systematic reviews of finite element models and checklists for fidelity.

Keywords: finite element model; simulation; validation and verification; mesh convergence; uncertainty analysis

1. Introduction

The finite element method or analysis is a computational tool or numerical simulation to solve complex engineering and mathematical problems. The basic concept of the finite element method is to subdivide or discretize large and complex systems into smaller and simpler parts, named finite elements that locally approximate the original complex equations. This approach is advantageous in presenting complex geometry, including dissimilar materials, ease for computation, and analysis of local effects [1]. The finite element method was believed to be originated in the early 1940s for structural analysis problems in civil and aeronautical engineering, which was subsequently coined by Argyris and Clough in 1960 [2]. It was later widely used to design and develop engineering products to minimize the weight, materials, and costs that improved the design process and cycle [3].

Eventually, engineering has submerged in medicine with the finite element as one of the instigators. Dentistry or Orthodontics is one of the pioneers of biomechanics and biomaterial investigations using finite element methods that could hardly be achieved *in vivo* [4]. In the 1990s, there were more than 700 publications relating to finite element simulation on orthodontics, despite the scarcity in computer facilities by that time [5]. On the other hand, computational orthopaedics represented another major branch and has been applied for more than 40 years [6], particularly in the evaluations of knee and hip replacement designs [6-8]. With the advancement of computing power and software, the scope of computational orthopaedics has extended to the region composed of numerous sophisticated parts and complex loading conditions, including the spine [9] and the foot-and-ankle complex [8,10]. The versatile platform not only uncovered the mechanism of pathologies or injuries [9,11,12] but also dedicated to other applications, such as footwear design [13], surgical planning [14,15], implant customization [16,17], physiotherapeutic intervention [18], prosthetics, and

orthotics [19,20], and sports science and medicine [21].

While the impact of the finite element method in translational and pre-clinical research has been affirmed, there have been concerns about the quality of simulation papers. Some reviews on finite element methods pointed out that many simulation papers lacked adequate model verification and validation [22], while some studies were not actually modeling the pathological condition of interest and overclaimed the implications [11]. It is calling for some quality controls on the research using finite element analysis. For example, the journal, *Clinical Biomechanics*, imposed strict requirements on the inclusion of necessary components. Reports shall also be based on the specific question of clinical interest [23]. Similarly, the *Journal of Orthopaedic Translation* requires explicit statements to highlight the translational potential of the study. Some other clinical journals may regard subject-specific finite element models as a nonclinical study or a case study that are not welcome; otherwise, adequate sample size is required to attain a case series with a relative low level of evidence [24]. Furthermore, there has been lacking guidelines or quality assessment instruments for finite element models, whereas methodological quality assessment has been imperative and undeniable in systematic reviews, such as that on randomized controlled trials [25].

To this end, we propose an instrument, Methodological Quality Assessment of Subject-Specific Finite Element Analysis Used in Computational Orthopaedics (MQSSFE), which aimed to evaluate methodological quality on finite element studies, particularly on the inclusion of critical elements. This paper would outline the development domains of the instrument and the evaluation of validity and reliability.

2. Materials and methods

2.1 Development of Instrument and Face Validity

The first author developed the instrument based on an integration of other methodological quality assessment instruments [26,27], and the incorporation of relevant review paper discussion [10,11,22]. The face validity of the instrument was facilitated by interviews with experts (the 5th, 6th, and 7th author) on finite element analysis. One biomechanical expert (the 4th author) that was not dedicated to finite element analysis was also interviewed to account for potential prejudice. The instrument was revised to make sure that it is understandable and trivial. Necessary remarks were added to help readers better answer the instrument items. The details of the MQSSFE is shown in Table 1 and attached in the Appendix.

2.2 Inter-rater Reliability

We planned to evaluate the inter-rater reliability of MQSSFE between two assessors (2nd and 3rd author) using a brief review of recent finite element study articles. The assessors were, respectively, postdoctoral fellow and Ph.D. candidate working on finite element analysis of the foot and ankle.

Literature search was conducted by the first author on the electronic database, ISI Web of sciences to retrieve finite element studies related to the foot and ankle in order to match the expertise of the assessors. The searches were conducted on 15 Dec 2020 using the keywords “finite element” AND (“foot” OR ankle”) in the topic field. The articles shall be original research in English, published in 2020, under the SCI category and orthopaedics research area. Articles that were not dedicated to a clinical condition or intervention were excluded. There were nine articles eligible for the review. Three out of twelve articles from the initial search were excluded because they were either not describing a clinical condition or did not consider any human body parts in the model.

Reliability was determined by the correlation coefficient, ICC (2,1), absolute agreement for the total score of MQSSFE. An ICC of above 0.75 was considered as good and acceptable reliability [28].

2.3 Criterion Validity

Besides, the two assessors also completed a modified version of the Down and Black instrument [26] and compared to that of the MQSSFE to facilitate the evaluation of criterion validity. The Down and Black instrument was a checklist to evaluate the quality of reporting, power, internal and external validity for randomized and non-randomized studies in healthcare interventions [26]. The original instrument consisted of 27 questions. However, it was commonly modified to accommodate different scope of studies, such as sports [29] and psychiatry [30]. For the modified Down and Black instrument, the original 27 Items were crunched down to 12 items. Item 8, 9, 14, 15, 17, 19, 21, 22, 23, 24, and 26 were excluded because they were not applicable to the study design of the finite element model. Item 7, 11, 18, 25, and 27 were excluded because these items were related to statistics that did not apply to single-subject design. The Spearman rank correlation test was run to determine the correlation between the total scores of MQSSFE and the modified Down and Black instrument.

3. Results

3.1 Outline of the instrument

There were a total of 37 items in the instrument that are categorized into six domains. They include study design and presentation of findings (item 1 to item 8), subject recruitment (item 9 to 12), model reconstruction and configuration (item 13 to 20), boundary and loading

conditions, simulation (item 21 to 26), model verification and validation (item 27 to 31), and model assumption and validity (item 32 to 37).

For the study design and presentation of findings, a clear and well-defined research hypothesis, aim, or objective is crucial in the introduction (item 1). Next, item 2 and item 3 accounted for the data dredging issues. If the study is exploratory without a well-defined and justified set of outcome parameters (data dredging), the spectrum of the endpoints shall be justified (item 3). Also, the critical information, including outcome measures (item 4 and item 6), time-points (item 5), and key findings (item 7 and item 8), shall be described clearly and correctly.

For the domain of subject recruitment, Item 9 and item 10 describe the model subject's characteristics. Item 11 determined whether the subject recruitment is appropriate, while item 12 noted whether the studies have described the relevant clinical conditions clearly.

Item 13 to item 20 examine the description of the model reconstruction and configuration process, including model reconstruction modality (item 13) and specifications (item 14), the control of model reconstruction, alignment, and assembly process (item 15 to item 17). The mesh creation, material property, and interaction property shall also be clearly stated (item 18 to item 20). On the other hand, the boundary and loading conditions shall be clearly described (item 21). The simulation scenario shall reflect the common activity or load case of the targeted clinical conditions (item 22) with appropriate and sufficient assignment of loading conditions, such as muscle force and ground reaction force, ideally acquired from the model subject (item 23 to item 25). Eventually, the type of analysis (static or dynamic) and the software used for the analysis shall be explicitly declared.

Model verification and validation play an essential role in finite element analysis. The processes and the results for model verification and validation shall be described clearly (item 27 to item 30). Some studies may also compare the findings with existing relevant studies (item 31). Besides, model assumption and simplification shall be discussed in the limitations, including those on model reconstruction/configuration and material properties (item 32), boundary and loading conditions (item 33), and model validation and verification (item 34). Furthermore, how the findings of the finite element model could be translated into applications shall be mentioned with the internal and external validity of the findings addressed (item 35 and item 36).

3.2 Demonstration of MQSSFE

As shown in Table 2, a literature review on the finite element studies of the foot and ankle. Nine eligible articles were retrieved for analysis [18,31-38]. One study investigated foot pathology [30] while another study targeted on a physiotherapeutic intervention [18]. The other studies were related to surgical interventions [31-35,37,38]. A simple loading case, standing, was adopted in most of the literature, while Chen et al. [18] simulated a relatively complicated running scenario. Some other studies explored the biomechanics in the different foot-ankle positions [37,38].

In terms of the outcome of the MQSSFE (Table 3), the average total score was 21.3 (range 17 to 34.5). The papers generally performed well in the description of technical context, including key findings (item 7), technical specification and the process of model reconstruction (item 14 and item 16), material properties (item 19), boundary and loading conditions (item 20), and interactions (item 21). They also addressed the model assumption in reconstruction and material properties (item 32) and avoided unplanned analysis (item 2). However, the papers generally lost points in justifying or supporting the internal and external

validity of the study (item 11 and item 36). They seemed to avoid discussing the limitations regarding model validation (item 34). Some studies did not describe the relative position or assembly of the implant clearly (item 17). Most of the studies simulated standing only, which may not adequately represent the common loading conditions (such as walking) in daily activities (item 22). Also, muscle forces were often neglected or overly simplified (item 24 and item 25).

3.3 Inter-rater reliability

There was no statistically significant difference in the total MQSSFE scores between the two assessors ($p = 0.842$). The intraclass correlation coefficient, ICC (2,1), was 0.965, 95%CI 0.855 to 0.992, which indicated good and acceptable reliability.

3.4 Criterion validity

There was a positive, large, and significant association level ($r = 0.61$, $p = 0.007$) between the MQSSFE scores and the modified Down and Black score [26]. However, it shall be noted that MQSSFE assessed more constructs than the modified Down and Black instruments.

4. Discussion

Physicians are increasingly counting on computational methods, such as the finite element model, to provide insights on orthopaedic sciences and the design of implants or other devices. Computational methods put less physical, financial, and technical constraints that can complement traditional *in vivo* or *in vitro* experiments [39]. However, compared to clinical trials, simulation studies imposed less cost and loosely regulated, could be easily abused, and were criticized for the lack of quality control. Some researchers could take advantage of the convenient tool for tweaking output by tuning different materials or loading conditions using overly simplified and inaccurate models without adequate verification and

validation. It was believed that the complex finite element models are highly susceptible to the "garbage-in, garbage-out" phenomenon since the outputs are highly dependent on the quality of the input and model [39]. In fact, computational methods play an important role in translational medicine to inform design and practice. The consequence of poor-quality studies or malpractice could be disastrous. It is imperative and calling for an instrument or checklist to substantiate the fidelity and the clinical utility of the simulation.

Our 37-item MQSSFE has demonstrated adequate reliability and validity. However, the evaluation process had focused on the finite element models of the foot and ankle; nevertheless, we envisioned that the instrument could be applied to other areas in computational orthopaedics. It shall be noted that different areas in computational orthopaedics may have different interests and thus endpoints. For example, investigations on implants may focus on the tribology and wear of the implant [40]. Simulations of some body parts were compelled to indirect validation due to experimental constraints [41]. On the other hand, we did not evaluate construct validity and internal consistency because we believed that the scale did not manifest any abstract construct. The items within each domain could also be independent.

Model credibility is of utmost importance for clinicians or scientists to extrapolate implications and decisions based on the model predictions [42]. In order words, they shall warrant sufficient accuracy or reliability for the intended use [42] and closely resemble the concepts of internal and external validity in clinical studies. There are three concerns regarding model credibility. The first concern is the correctness of the model or the calculation. Secondly, the accuracy of the model prediction shall be adequately accurate to answer the scientific question. Thirdly, potential errors and uncertainties inherited in the model prediction shall be addressed since the reality of interest is always stochastic while the model prediction is naturally deterministic. Model verification and validation represent ways

to identify and account for errors or uncertainties due to model implementation and formulation [41].

Model verification justifies the accuracy of the mathematical model and its solutions [43]. While we always assumed that the finite element code has been verified by the software developing companies, errors are sourced from the discretization of geometry or analysis time [41]. Model verification is contemplated by the mesh convergence test, which is often concluded by the size and the number of elements or nodes after an iterative refinement of mesh quality on the percentage change of a solution parameter [41]. Model verification using mesh convergence test is highly recommended since it provides information on the baseline discretization error for the readers [41]. Research on some complicated models, such as the spine and the foot-and-ankle complex, suggested that the mesh refinement could be regarded as sufficient when the change of the output solution was less than 5% [44,45].

Model validation is the process of determining the degree of the model that can accurately represent the reality of interest for the intended use [41]. Since the origin of the computational model is to simulate phenomena that cannot be easily measured experimentally or with unknown model inputs [22], some researchers compromised the definition and approach of model validation. It shall compare the model prediction to the golden standard (i.e., physical experiment data) for the evaluation of modeling error [42]. Validation experiments or direct validation are specifically designed for comparison rather than to address the scientific hypothesis [42]. Therefore, the validation process does not assume that physical experiments are more accurate and reliable to manifest the reality of interest [42,46]. Ideally, the validation experiment or metric shall be directly related to the research problem or primary outcome [42,46]. Given the paradox of the necessity of simulation if physical experiment could be arranged, the central problem of validation experiment is always on time, cost, feasibility, and complexity. Often, lower-order data

(instead of the primary outcome) are treated as the validation metric to provide fundamental confidence. In this case, additional evidence or other measurement data shall be supplied to improve model credibility [42,44]. Besides, indirect validation is another alternative that compares the prediction outcomes to existing literature, which are less favorable since the quality control, errors, and variability are unknown [42,44].

Qualitative observation on the fringe plots was used to relate the model to the experimental findings and thus facilitate validation. Therefore, a consistent color or fringe scale is essential. A typical example is the plantar pressure distribution at different walking phases [47]. Statistical analysis on validation could be conducted by the measure of correlation, ideally enforcing the slope of the regression line as one [41]. Nevertheless, Bland and Altman [48] opposed the approach because the measure of agreement shall be adopted. They proposed a form of analysis (Bland-Altman plot) to account for repeatability and reproducibility.

Study designs are critical elements in clinical research. Researchers may plan to conduct a case-control or cohort trial; recruit subjects, and assign them into targeted or control groups in clinical studies. Some demanding study designs, such as the randomized controlled trial, are designed to address the internal and external validity issues. In the computational study, particularly for single-subject design, the same method may not be applicable. Instead, researchers manipulate the input variables of the single-subject model in simulation and postulate the responses using the design of computer-based experiment approach [6]. While a simple comparative analysis compares the performance of two or more conditions, parametric analyses are often implemented to understand the severity of the pathology or impact of design parameters [47,49,50] using a full or fractional factorial approach [50,51]. The approach sweeps the effect of the clinical or design features and understand its contribution, whilst keeping the other parameters constant [6]. In lieu, some

studies adopted a similar approach but prefer the probabilistic technique (Monte Carlo Approach) to generate input by a defined distribution [52]. Besides targeting the primary research interest, parametric analysis could also be used to explore the sensitivity of modelling assumptions, such as modelling, surgical, and patient variability, that correspond to internal and external validity considerations (item 35 and 36). The significance of sensitivity analysis lies in its potential to quantify the uncertainty or validity of the input to better understand their influence on model prediction [42].

The single-subject and subject-specific approach is a typical study design in the finite element analysis that hindered the external validity or the generalizability of the findings. Some research adopted population-based subject-specific models [53,54]. However, this method may not be feasible to apply in some sophisticated models or models with complex boundary and loading conditions. While some research dedicated to the development of statistical models [55], most of the studies claimed that the model subject was representative of the population to account for the generalizability and endeavoured to improve internal validity by mesh convergence test, uncertainty or variability analysis [49,56]. However, the single-subject subject-specific nature of the study is often confined to the geometry and model reconstruction. Some studies overlooked or adopted loading conditions or muscle forces from other sources instead of the model subject. Besides, some clinical conditions often use a modified version of the normal model as a surrogate, which may not adequately represent the clinical features and shall be interpreted carefully.

5. Conclusions

Model fidelity is imperative to the credibility and translation potential of the model prediction. In this study, we developed an instrument to evaluate the methodological quality for single-subject finite element studies dedicated to the area of orthopaedics. The instrument

was optimized in face validity section and demonstrated good reliability and validity in the intraclass correlation and criterion validity tests. The instrument highlights the necessity in the clear description of critical elements in finite element analysis. Moreover, it also stressed the importance of the study design, validation, verification, and uncertainty analysis to determine the limits of model application and to prevent over-extrapolation of findings. The instrument can facilitate quality assessment in the systematic reviews of finite element models and checklists for fidelity.

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Conflict of Interest Statement

W-K.L. is an employee of Li Ning Sports Goods Company Limited. The company had no role in the design of this study, execution, analyses, interpretation of the data or decision to submit results. There is no direct connection and conflict of interest to this article. The other authors declare that there are no conflicts of interest.

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Tables

Table 1 Methodological Quality Assessment of Single-Subject Finite Element Analysis Used in Computational Orthopaedics (MQSSFE)

	Question	Yes	No	Score
Study Design and Presentation of Findings				
1	Was the hypothesis/aim/objective of the study clearly described?			
2	Were all analyses planned at the outset of study? *Answer NO for unplanned analysis/sub-analysis, unable to determine.*			
3	If data dredging (establish objectives, hypothesis and endpoint parameters without scientific reason) was used, was the spectrum of the data justified by any concepts? *Answer YES if no data dredging, NO if unable to determine*			
4	Were ALL the outcome measures and parameters (including all data reduction methods or derived parameters) clearly described and defined in the Objectives or Methods section? *Answer NO if they are only defined in results or discussion*			
5	Were the time points or period for ALL the outcome measures clearly described? *Answer YES if not applicable*			
6	Were the main outcome measures appropriate to describe the targeted conditions ? *Answer NO if unable to determine*			
7	Were the key findings described clearly?			
8	Were ALL the contour plots that were used for comparison presented with the same colour scale?			
Subject Recruitment				
9	Were the characteristics of the model subject clearly described?			
10	Were the principal confounders of the model subject clearly described ? (Age, sex, or body weight, and height)			
11	Was the model subject participated in the study representative of the population with the targeted clinical conditions or demographic features ? (e.g. answer NO if simulating a pathology by modifying a normal subject model; or scaling an adult model to a child model)			
12	Were the targeted intervention or clinical condition clearly described ? (with details in the severity, class, design/dimensions of implants, or details in surgical surgery)			
Model Reconstruction and Configuration				
13	Was the model reconstruction modality for the body parts and ALL other items, such as implants, clearly described (e.g. MRI, 3D-scanning, CAD) ?			
14	Were ALL important technical specifications (e.g. resolution) for the reconstruction modality clearly described ?			
15	Was the posture or position of the body parts controlled during the acquisition process (e.g. MRI, CT) of the model reconstruction ?			

16	Were the model reconstruction methods for ALL components clearly described including those requiring additional procedures (e.g. connecting points for drawing ligaments from MRI)?			
17	Were the orientation or relative position among the components of the model assembly (where appropriate) clearly described? *Answer YES if not applicable*			
18	Was the type of mesh for ALL components, including the order of magnitude of the elements, clearly described ?			
19	Were the material properties for ALL components clearly described and justified ? (e.g. with reference)			
20	Were ALL the contact or interaction behaviours in the model clearly described and justified?			
Boundary and Loading Condition (Simulation)				
21	Were the boundary and loading conditions clearly described ?			
22	Was the boundary and loading condition sufficiently simulating the common activity/scenario of the conditions ? (e.g. if the research or inference is targeted to ambulation or daily activities, simulations of balanced standing or pre-set compressive load are not sufficient)			
23	Was the model driven by the boundary and loading conditions acquired from the same model subject?			
24	Was loading condition on the scenario sufficiently and appropriately considered in the simulation? (e.g. muscle force, boundary force, inertia force)			
25	Was the loading condition acquired from the same model subject?			
26	Were the software (e.g. Abaqus, Ansys), type of analysis (e.g. quasi-static, dynamic), AND solver (e.g. standard, explicit) clearly described ? (solver can be regarded as clearly described if it is obvious to the type of analysis)			
Model Verification and Validation				
27	Were the methods of mesh convergence or other verification tests conducted and clearly described?			
28	Were the model verification conducted and results presented clearly; and that the model was justified acceptable ?			
29	Were direct model validation (with experiment) conducted and described clearly? *Answer YES if the authors had direct model validation previously with reference.*			
30	Were the model validation conducted and results presented clearly; and that the model was justified acceptable ?			
31	Were the model prediction or validation findings compared to relevant studies ?			
Model Assumption and Validity				
32	Were the model assumptions or simplifications on model reconstruction/configuration AND material properties discussed?			
33	Were the model assumptions or simplifications on the boundary and loading conditions discussed?			

34	Were the limitations of model validation discussed? (e.g. differences in case scenario; differences between validation metric and primary outcome)			
35	Was the limitation on external validity, single-subject, and subject-specific design discussed?			
36	Were there any attempts to improve or discuss internal validity (such as mesh convergence test), uncertainty and variability in the study?			
37	Was there any discussion, highlights or content on the implications or translation potential of the research findings? *Answer NO if there are only bold claims without making use of the result findings or key concepts*			
			Sum:	

Yes scores one point; No scores zero point.

491 Table 2. Literature review of recent finite element studies of the foot and ankle.

Author	Clinical problem	Simulation Scenario	Outcome measures
Can et al [38]	Tenodesis reconstruction, including Pisani interosseous talocalcaneal ligament, Schon cervical ligament, Choisne calcaneofibular ligament, Schon triligamentous, and Mann triligamentous reconstruction	Different ankle positions	Kinematics of subtalar joint, contact pressure of subtalar joint, stress in reconstructed grafts
Cifuentes-De La Portilla et al [31]	Midfoot fusion for adult acquired flatfoot, including, talonavicular joint, naviculocuneiform, and cuneometatarsal joint	Standing	Spring ligament stress, arch height, arch length
Cifuentes-De La Portilla et al [32]	Hindfoot joint arthrodesis for adult acquired flatfoot, including talonavicular arthrodesis, calcaneocuboid arthrodesis, triple arthrodesis	Standing	Maximum principal stress of spring ligament, forefoot bones, and hindfoot bones
Chen et al [18]	Fascia taping, low-dye taping	Running	Maximal strains of the proximal, middle and distal plantar fascia, maximal subtalar eversion, minimal navicular height
Fan et al [33]	Four screw fixations for talus neck fracture, including dual screws and cross screws in anteroposterior and posteroanterior directions	Single-leg standing	Maximum stress and maximum displacement of talus and fixation.
Qiang et al [34]	Different placement of sustentaculum screw for calcaneal fractures	Standing	Von Mises stress, contact area and maximal displacement of the subtalar joint
Ramlee et al [35]	External fixator for pilon fracture under normal, osteoarthritis, and osteoporosis conditions	Stance and swing	Von Mises stress and displacement for bones and fixator
Van Zwan et al [36]	Heel ulcers for bedridden patients	Different foot postures on	Contact pressure and maximum shear strain of the heel and calf

		bed	
Wang et al [37]	Five kinds of three-screw configuration used for ankle arthrodesis in traumatic ankle arthritis, including	Midstance, standing, dorsiflexion, internal and external rotation of ankle	Von Mises stress of tibia and talus, maximum and average micromotion and pressure of the tibiotalar surface

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494 Table 3 Demonstration of MQSSFE for nine reviewed articles

	Can et al [38]	Cifuentes-De La Portilla et al [31]	Cifuentes-De La Portilla et al [32]	Chen et al [18]	Fan et al [33]	Qiang et al [34]	Ramlee et al [35]	Van Zwan et al [36]	Wang et al [37]	**Sum**
1	?	?	?	+	-	+	?	?	?	5
2	+	+	?	+	+	+	+	+	+	8.5
3	+	?	?	+	-	+	+	+	+	7
4	-	-	-	+	-	+	-	+	+	4
5	+	?	?	+	+	+	-	+	+	7
6	+	?	-	+	+	+	+	+	+	7.5
7	?	+	+	+	+	+	?	+	+	8
8	+	-	?	+	-	+	+	-	-	4.5
9	+	?	+	+	+	+	-	+	+	7.5
10	+	?	+	+	+	+	-	?	+	7
11	-	-	-	+	-	-	-	-	-	1
12	+	?	?	+	+	-	+	+	+	7
13	+	?	?	+	+	-	+	+	+	7
14	+	+	+	+	+	+	+	+	+	9
15	-	-	-	+	+	-	-	-	+	3
16	+	+	+	+	+	+	+	+	+	9
17	?	-	-	?	?	-	-	?	?	2.5
18	-	-	-	+	-	-	+	+	+	4
19	+	?	?	+	+	+	+	+	+	8
20	+	?	?	+	+	+	+	+	+	8
21	+	+	+	+	+	+	+	+	+	9
22	-	-	-	+	-	-	?	?	-	2
23	-	-	-	+	-	-	-	?	-	1.5
24	-	?	?	+	-	-	-	-	-	2
25	-	-	-	+	-	-	-	-	-	1
26	?	?	?	+	-	-	?	?	+	4.5
27	+	+	+	+	-	-	-	+	?	5.5
28	+	?	?	+	-	-	-	-	-	3
29	?	+	+	+	-	-	-	?	-	4
30	+	?	?	+	-	-	-	-	-	3
31	+	?	?	+	-	+	+	+	-	6
32	+	+	?	+	+	+	+	+	+	8.5
33	-	+	?	+	+	-	+	-	-	4.5
34	-	-	-	-	-	-	-	-	?	0.5
35	+	-	?	+	+	-	-	+	+	5.5
36	-	-	-	-	-	-	-	-	?	0.5
37	?	?	?	+	+	-	?	+	+	6
Sum:	23	17	17	34.5	18.5	17	17.5	23.5	23.5	

495 +: Both assessors scored the item; −: Both assessors did not score the item; ?: The assessors
496 gave inconsistent results