Assessment of Severity in Ankle Osteoarthritis Using Bone Single-Photon Emission Computed Tomography/Computed Tomography Quantification

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INTRODUCTION:

Single-photon emission computed tomography/computed tomography (SPECT/CT) is useful for the diagnosis of bone metastases and bone tumors. Recent years have seen an increased number of reports on its use in the evaluation of painful areas. Accurate identification of bone lesions is important in the treatment of ankle and foot diseases, given that the foot is composed of several bones and joints. In this context, bone SPECT/CT which strongly accumulates in bone lesions can be a useful diagnostic tool. In the past, SPECT/CT was mainly analyzed by non-quantitative methods using relative intensity; however, in recent years, quantification has made it possible to add objectivity to the data. The study aimed to quantify bone SPECT/CT accumulation in ankle osteoarthritis (OA) and investigated the relationship of quantitative values with severity of deformity and pain.

METHODS: Twenty-seven patients (27 ankles) with OA who underwent bone SPECT/CT between July 2018 and July 2021 were retrospectively studied. The average age was 65.0 years, with 9 males and 18 females. All patients underwent surgical treatment, and the tests were performed preoperatively. Using Takakura-Tanaka classification which is an index of OA progression, two patients were classified as having stage 2, ten as stage 3a, five as stage 3b, six as stage 4, and four as the valgus type, which did not fall into these categories (Figure.1). For SPECT/CT evaluation, the intensity of the accumulation in the area from the distal tibia to the hindfoot was quantified as the standardized uptake value (SUV). We defined SUV peak (SUVp) as the average of SUV of 1 cm^3 around the point of maximum SUV in the region. This is considered an indicator of lesion intensity. The total bone uptake (TBU) was defined as the quantitative value calculated by multiplying the SUV by the accumulation range, where the SUV was more than 20% or 40% of the maximum value (Figure.2). This is considered an indicator of lesion extent. To assess preoperative pain, we used the "pain" item (0-100 points, with a lower score denoting a higher pain rating) of the Self-Administered Foot Evaluation Questionnaire (SAFE-Q), a patient-administered evaluation questionnaire in Japan. The association between SUVp or TBU and OA stage or SAFE-Q was examined. For statistical analysis of SUV and TBU by OA stage, Bonferroni's multiple comparison test was used, with $p<0.05$ being considered significant. Pearson's correlation coefficient was used for the correlation between the SUV peak or TBU and pain score (SAFE-Q), with $r > 0.4$ being considered a moderate association and $r > 0.7$ a strong association.

RESULTS:

SUVp, 40% TBU, and 20% TBU at each OA stage are shown in the table (Table.1). SUVp was 7.3 for Stage 2, 10.09 for Stage 3a, 14.12 for Stage 3b, 16.65 for Stage 4, and 13.86 for Valgus type. Forty percent TBU was 47.61 for Stage 2, 124.44 for Stage 3a, 222.73 for Stage 3b, 279.58 for Stage 4, and 192.32 for Valgus type. Twenty percent TBU was 103.2 for Stage 2, 264.3 for Stage 3a, 392.6 for Stage 3b, 539.8 for Stage 4, and 420.3 for Valgus type. In all three items, significant differences were found between Stage 2 and Stage 4, and Stage 3a and Stage 4.

The correlation between the preoperative pain score of SAFE-Q and the three items is shown in the graph (Figure.3). Using Pearson's correlation coefficient, we found a moderate association between pain score and SUVp at -0.41, but no association with TBU at -0.23 or -0.21.

DISCUSSION AND CONCLUSION:

To my knowledge, this is the first study to quantify and objectively evaluate SPECT/CT accumulation in ankle osteoarthritis. This study showed that TBU and SUVp tended to increase with the progression of OA stage in bone SPECT/CT. In addition, the correlation with pain score was stronger with SUVp than with TBU. This result suggests that the subjective pain in patients tends to be more related to local lesion intensity than lesion extent. Because the foot is composed of many bones and joints, one of the problems that plague orthopaedic surgeons is the extent to which to treat when the lesion is large. However, quantification of bone SPECT/CT accumulation allows objective evaluation and may help in the selection of treatment strategies by making it easier to assess the location and severity of pain.
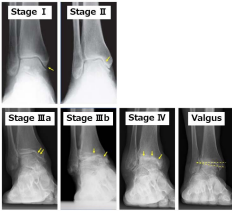
< Figure 1 >
Takakura-Tanaka classification :
Stage 1) no narrowing of the joint space, but early sclerosis and formation of osteophytes;
Stage 2) narrowing of the medial joint space
Stage 3) obliteration of this space with subchondral bone contact
    3a) obliteration of the joint space is limited to the medial malleolus
    3b) the obliteration extends to the roof of the dome of the talus
Stage 4) obliteration of the whole joint space with complete bone contact
Valgus type is not included in this classification.
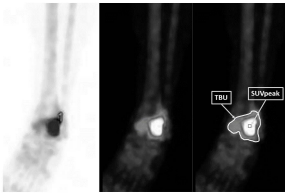
< Figure 2 >
SUV peak is the average of SUVs of 1 cm² around the point of maximum SUV in the region.
TBU is the quantitative value calculated by multiplying the SUV by the accumulation range, where the SUV was more than 20% or 40% of the maximum value.
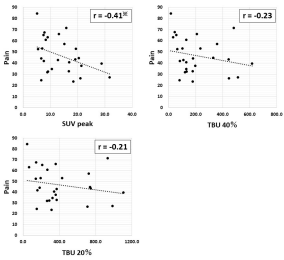
< Figure 3 >
The correlation between the preoperative pain score(SAFE-Q) and the three item.
※ |r|>0.4 : moderate association, |r|>0.7 : strong association

Stage	N	SUV peak mean	40% TBU mean	20% TBU mean
Total	27	13.77	208.11	406.02
2	2	7.30	47.61	103.22
3a	10	10.09	124.44	264.28
3b	5	14.12	222.73	392.64
4	6	16.65	279.58	539.76
Valgus	4	13.86	192.32	420.32

< Table 1 >
This table shows SUVp, 40% TBU, and 20% TBU at each OA stage.