

Digital photography for the diagnosis and grading of hand osteoarthritis

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Abstract:

Background: Osteoarthritis of hand(HOA) is an underestimated disorder that commonly involves the distal and proximal interphalangeal joints and the carpo metacarpal joints(DIP, PIP and CMC) of the hand resulting in pain and physical disability requiring the use of non-steroidal anti-inflammatory drugs and sometimes surgical intervention too. In addition to symptoms directly related to the hand itself, it is also related to osteoarthritis at other sites and there is evidence that the presence of Hand OA increases the propensity for the development and progression of both knee and hip OA. This relationship is usually referred to as "generalized osteoarthritis". The imaging of the disease progress is done through radiography which is the golden standard for diagnosing OA. Other modalities such as MRI, scintigraphy are more dynamic and advance yet expensive and thus only radiography is widely used for the diagnosis and grading of the severity. Hand photography has been considered as a modality in recent studies and has the advantage of being inexpensive, involving no ionizing radiation or discomfort, and involves easy interpretation.

Materials and methods: In this cross sectional study we used photographs to grade HOA and to correlate the findings with radiological and clinical examination. This cross sectional study was conducted in the Department of Orthopaedic surgery OPD during July-August 2018. A total of 40 hand osteoarthritis patients were chosen for this study considering the incidence rate.

Results: The photographic findings demonstrated strong correlation with those that were obtained from the radiographic and the clinical methods.

Conclusion: Digital photography of hand can be utilised for the diagnosis and grading of hand osteoarthritis.

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I. Introduction:

Osteoarthritis (OA) is a progressive joint disease characterized by joint inflammation and a reparative bone response and is a disabling condition that affects more than one-third of persons above 65 years of age. Global estimates reveal more than 100 million people are affected by OA, with a prevalence of 22% to 39% in India¹. Osteoarthritis of hand(HOA) commonly involves the distal and proximal interphalangeal joints and the carpo metacarpal joints(DIP, PIP and CMC) of the hand which results in pain and physical disability requiring the use of non-steroidal anti-inflammatory drugs and sometimes surgical intervention too². In addition to symptoms directly related to the hand itself, it is also related to osteoarthritis at other sites and there is evidence that the presence of Hand OA increases the propensity for the development and progression of both knee and hip OA³. This relationship is usually referred to as "generalized osteoarthritis"⁴.

The imaging of the disease progress is done through radiography which is the golden standard for diagnosing OA. Other modalities such as MRI, scintigraphy are more dynamic and advance yet expensive and thus only radiography is widely used in studies^{5,6}. But for various other studies, the AGES-Reykjavik Study provided an extensive database of hand photography information, based on visible features such as hard tissue enlargement, soft tissue swelling, altered position, pain and deformity which occur secondary to the pathology behind the disease process⁷.

Hand photography is a simple method having the advantages of being inexpensive, involving no ionizing radiation or discomfort, and involves easy interpretation⁹. Hence this study aims to use photographs to diagnose and grade HOA and to correlate the findings with radiological and clinical examination.

II. Review of literature:

Hand osteoarthritis is significant as it can cause disablement without much symptoms in the elderly. Out of 80% people diagnosed with radiological osteoarthritis, only 58% showed symptoms. There are evidences where the hand osteoarthritis can predispose to the development of osteoarthritis of other joints in cases of inherited

phenotypes such as GOA- 'Generalised osteoarthritis' and in genetic mutations like polymorphism of Genetic differentiation factor 5 (GDF5).⁽⁴⁾⁽¹³⁾ According to Dahaghin S, et al, the presence of hand osteoarthritis showed an increase in the risk of future hip/knee OA (higher for hip OA than knee OA) comparing with those who had no prior hand osteoarthritis.⁽¹⁴⁾

OA is joint failure, a disease in which all structures of the joint have undergone pathologic change. The pathologic sine qua non of disease is hyaline cartilage loss, accompanied by increasing thickness and sclerosis of the subchondral bony plate, by outgrowth of osteophytes at the joint margin, by stretching of the articular capsule, by mild synovitis in many affected joints, and by weakness of muscles bridging the joint. The initial step is often joint injury in the setting of a failure of protective mechanisms.⁽¹⁵⁾

Joint capsule and ligaments, muscle, sensory afferents, and underlying bone serve as joint protectors by providing a limit to excursion. Synovial fluid reduces friction between articulating cartilage surfaces where the lubrication depends on hyaluronic acid and lubricin.⁽¹⁵⁾

Muscles and tendons that bridge the joint are key joint protectors which exert focal stress across the joint in minimizing the muscle contraction that decelerates the joint before impact and assures that when joint impact arrives, it is distributed broadly across the joint surface. Failure of these joint protectors increases the risk of OA.

Mechanical and osmotic stress on chondrocytes induces these cells to alter gene expression and increase production of inflammatory cytokines and matrix-degrading enzymes. While chondrocytes synthesize numerous enzymes, matrix metalloproteinases (MMP) (especially collagenases and ADAMTS-5) are the critical enzymes breaking down the cartilage matrix.⁽⁸⁾

As the osteoarthritic process develops, their activities and effects spread throughout the matrix, especially in the superficial layers of cartilage. The synovium, cartilage, and bone all influence disease development through cytokines such as interleukin (IL) 1 β , and (TNF) α , prostaglandin E2 and nitric oxide, which have complex effects on matrix synthesis and degradation.

Growth factors are also part of this complex network, with BMP-2 and transforming growth factor β playing prominent roles in stimulating the development of osteophytes. Whereas healthy articular cartilage is avascular in part due to angiogenesis inhibitors present in cartilage, disease is characterized by the invasion of blood vessels into cartilage from underlying bone and proliferation of vessels within synovium.⁽¹⁵⁾

These risk factors ultimately lead to the initiation of pathology starting the surface fibrillations and irregularity in cartilage. As disease progresses, focal erosions develop leading to subchondral cyst formation. The subchondral bony plate beneath the cartilage becomes activated by the growth factors, cytokines, osteoblasts and osteoclasts resulting in the formation of osteophytes, the hallmark of OA.

The measures of the disease activity and progress are complex. Particularly, imaging has been problematic. Radiography has been considered the gold standard for diagnosis and monitoring of HOA, but the method is basically a delayed reflection of damage and repair caused by OA and gives only little information about prognosis. Other modalities such as scintigraphy, ultrasound and magnetic resonance imaging (MRI) have the advantage of being more dynamic and a better indicator of disease activity. But for reasons including cost, availability and interpretation, none of them is likely to replace radiography in larger studies.^(5,6)

AGES Reykjavik et al, used hand photography for documenting the the osteoarthritic changes in the hand and grading the severity⁽³⁾. Helgi Jonsson et al had studied the age related prevalence based on hand photographic score.⁽¹⁷⁾

The most commonly affected joints in hand are the second distal interphalangeal joint and third proximal interphalangeal joint and the first carpometacarpal joint. These joints are looked for hard tissue enlargement, soft tissue swelling and deformities and graded through photographs. Hence, this study makes use of the hand photography to assess the severity of hand osteoarthritis and in comparing this modality with the radiography and clinical examination.

Objectives:

- To make use of a standard and reproducible grading system for the diagnosis of hand osteoarthritis from standard hand photographs.
- To compare the photographic scoring system with the two main diagnostic methods currently used: radiography and clinical examination.
- To analyze the relationship between the three methods and hand pain, the main symptom of hand osteoarthritis.

III. Material and Methods

This cross sectional study was carried out in the Out patient Department of Orthopaedics at Government Kilpauk Medical college hospital, Poonamalle high road, Kilpauk, Chennai, Tamilnadu from the month of July 2018 to August 2018. A total of 40 adult subjects both male and female aged ≥ 40 were in for this study.

Study design: Cross sectional study.

Study location: Department of Orthopaedics in our institution.

Study period: July – August 2018.

Study population: Patients OP in a tertiary care centre.

Sample size : 40 patients.

Calculation of sample size:

Formula: $n = Z^2(pq)$

d2

- $Z = 1.96$
- $p = \text{prevalence} = 26\%$
- $q = 1 - p$
- $d = \text{desired precision} = 15\%$
- Confidence level of 95%
- Power $(1 - \beta)$ of 80%

$n = 33$; adding non response of 10%, the sample size is 40. Considering the very less incident rate of Hand Osteoarthritis, we planned to conduct this study using a population size of 40 people.

Inclusion criteria:

1. Clinically diagnosed hand osteoarthritis patients.
2. Either sex
3. Aged ≥ 40 years

Exclusion criteria:

1. Arthropathies of other inflammatory conditions.
2. Dupuytren contracture.
3. Neuropathies.
4. Post-traumatic changes in the joints of fingers.

Procedure methodology:

Clinical examination:

After written informed consent was obtained from the patients, clinical examination of 2nd and 3rd Distal interphalangeal (DIP) joints, 2nd and 3rd Proximal interphalangeal (PIP) joints and the First Carpo-metacarpal (CMC1) joint of both the hands were examined and assessed based on the features such as Hard tissue enlargement, visible soft tissue swelling, position and deformity. All patients were examined by an experienced clinical examiner. They are then scored as

- 0 = No evidence of OA
- 1 = Suspected but not definite OA
- 2 = Moderate but definite OA
- 3 = Severe OA

Photographic scoring:

The photographs were taken using a Digital camera with images captured at resolution of 4200 x 2800 pixels. The camera was mounted on a fixed distance to a black velvet board with markers for thumb positioning and the photographs were obtained under identical light conditions with proper quality and proper positioning of the fingers. The photographs were then assessed based on the photographic features (HOAScore)⁷.

- 0 = No evidence of OA
- 1 = Suspected but not definite OA
- 2 = Moderate but definite OA
- 3 = Severe OA

The photographic score of the joints are then aggregated for further assessment and correlation.

Hand pain documentation:

Patients are questioned about hand symptoms with the following simple questions for assessment of the pain.

1. Have you ever had pain lasting atleast one month in the joints of your hands or wrist?
(ACR criterion for diagnosis of hand OA)
2. In the past 12 months have you had pain lasting atleast one month in the joints of your hands?
3. (a) Do you sometimes have pain in the joints of your hands?
(b) If yes, patients were asked to fill out a diagram showing where the joint pain was located.

Radiographic scoring:

Standard radiographs (X-rays) of both hands were taken. All radiographs were examined by single experienced Radiologist. The degree of radiographic OA in individual joints were graded based on Joint space narrowing, presence of Osteophytes, Sclerotic changes, Erosions and Subchondral cysts using the Kellgren-Lawrence scoring system(KL Score)

- 0 = Absent
- 1 = Doubtful
- 2 = Mild
- 3 = Moderate
- 4 = Severe

A score of more than 2 indicates definite sign of radiographic hand osteoarthritis.

Data collection procedures and instruments used:

Data collection was done using standard proforma and it is done by the principle investigator. All the examinations were performed using standard methods . A digital camera (CANON DIGITAL iXUS 960is) with 12 megapixels which records images of resolution 4200 x 2800 was used for taking the hand photographs. All anthropometric measurements were done using aplastic measuring tape.

Quality Control:

All examinations were done by experienced examiners. The intra and inter observer variations of the photographic examination were maintained.

Confidentiality:

Informed consent were obtained from all patients. Confidentiality and safety of all subjects were taken care of. Ethical committee approval was obtained from the Committee of Ethics, Government kilpauk medical college, Chennai, Tamilnadu, India on April-May 2018.

Statistical analysis:

Coded data were entered in excel sheets and analysed with SPSS 20 package:

- The severity of HOA is expressed as percentage with 95% confident interval.
- The correlation between other diagnostic methods and the digital photographic method isexpressed as correlation coefficient (spearman).
- t-test is used for testing significance.
- $p < 0.05$ is considered as statistically significant for two tailed test.

IV. Observation And Results:

This cross sectional study was conducted in the Department of Orthopaedicsurgery with 40 individuals chose based on the inclusion criteria, in an attempt to find the correlation of hand photography with radiography and clinical examination in diagnosing and grading hand osteoarthritis.

Table no1: Descriptive statistics of the various scores

	AGE	HOA SCORE	KL SCORE	CLINICAL SCORE	BMI	Pain
N Valid:	40	40	40	40	40	40
N Missing:	0	0	0	0	0	0
Mean:	56.825	4.375	2.150	1.450	23.475	1.625
Median:	58.000	4.000	2.000	1.000	23.500	2.000
Mode:	60.000	4.000	2.000	1.000	25.000	2.000

Std. Dev:	7.609	1.904	.893	.504	3.693	1.055
Minimum Value:	40.000	1.000	.000	1.000	17.000	.000
Maximum Value:	70.000	8.000	4.000	2.000	30.000	3.000

Table no 1 shows the total data collected from all the 40 hand osteoarthritis patients and their mean, median, mode, standard deviation, minimum and maximum values. These values are the scores obtained from the photographic, radiographic and clinical findings. BMI and pain in the hand were also taken into account to estimate any association with the findings.

The observed results were plotted in scatterplot, multiple variable histogram, disaggregation graph and Receiver operating characteristic curve since multiple variables are taken into account.

Table no 2: Scatterplot of KL SCORE and HOA SCORE:

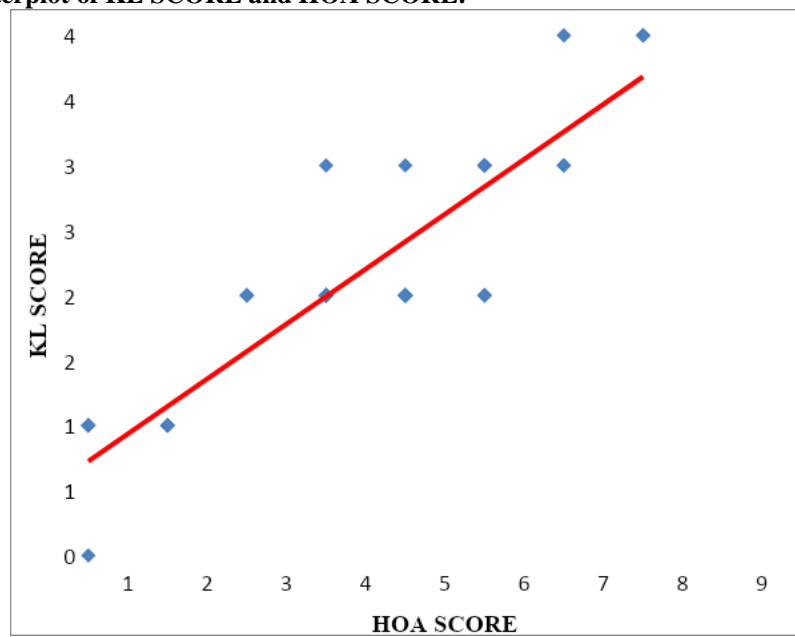


Table no 2 shows the correlation of the HOA score with that of the KL score. With $p = 0.000$, the observed HOA score of the patients showed to be significantly correlating with the Kellgren Lawrence score from the scatterplot. The radiographic findings showed strong association with the photographic findings.

Table no 3: Scatterplot of HOA SCORE and Clinical score

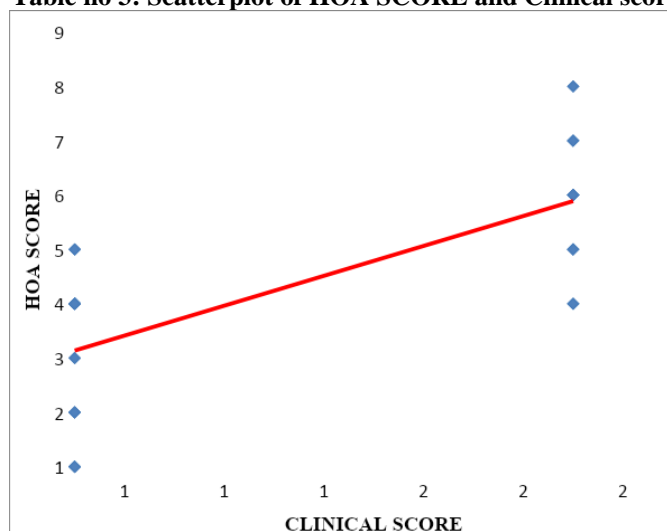


Table no 3 shows correlation of the HOA score with the clinical score. With $p=0.000$, the observed HOA score of the patients showed to be significantly correlating with the clinical score from the scatterplot. The clinical findings were in considerable relation with the photographic findings.

Table no 4 : EZAnalyze Results Report - Multiple Variable Histogram:

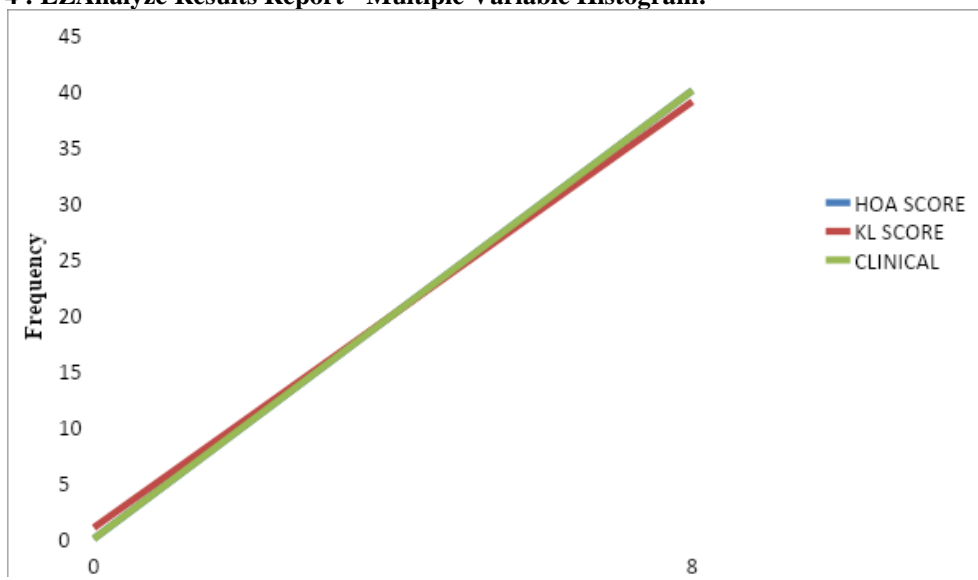


Table no 4 shows the multiple variable histogram of all the three scores. The significant overlap of all the three curves shows the strong correlation of the scores with each other thus proving the association of the photographic findings with the clinical examination and the radiographic findings.

Table no:5 Disaggregation Graph of BMI (Mean) By HOA:

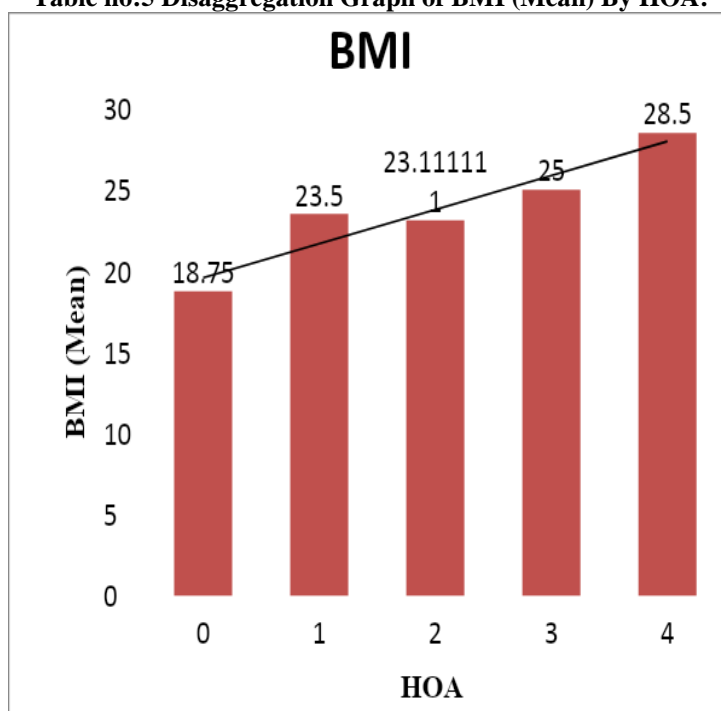


Table no: 6 Disaggregation Graph of BMI (Mean) By KL SCORE:

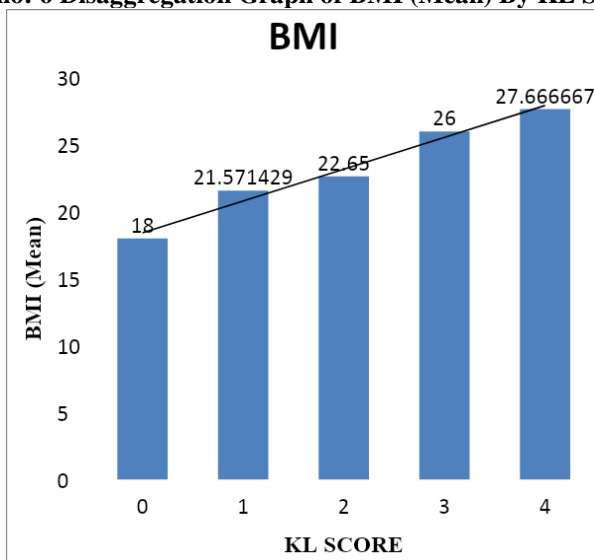


Table no 5 and 6 shows the disaggregation of mean BMI by HOA score and KL score. The disaggregation graph showed a more uniform rise in BMI with the KL SCORE comparing that of the HOA SCORE.

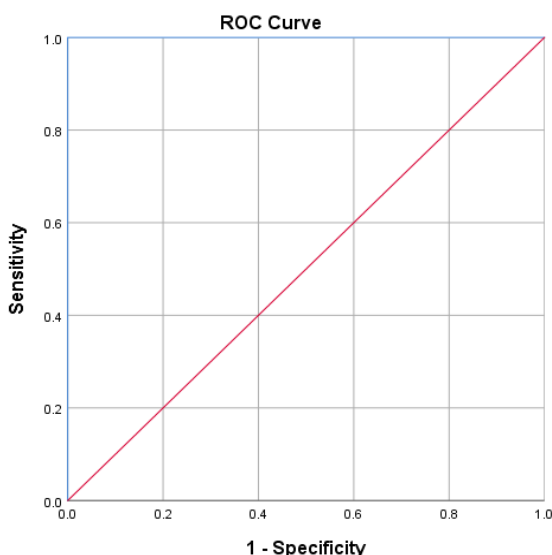


Table no 7: Receiver operating characteristic curve:

Table no 7 shows the ROC curve. Here, the curve overlaps the left and the top margin. Area under curve = 1. A value more than 2.5, showed an increase in severity of the disease. Thus with a cutoff value of 2.5, the sensitivity and specificity of HOAScore are 100% (for this sample size).

V. Discussion:

This study was done to assess the hand photographs for hard tissue enlargement, visible soft swelling, position and deformity in the fingers of hand osteoarthritis patients and to correlate with KL Score and Clinical Examination, in Department of Orthopaedicsurgery, in our institution. This cross sectional study includes 40 patients with clinically diagnosed hand osteoarthritis. Patients were taken in the age group of 40 to 70. The mean age of the patients is 56.825 with a standard deviation of 7.609.

The exclusion criteria includes arthropathies of other inflammatory conditions, dupuytren contracture, neuropathies and post-traumatic changes in the joints of fingers. A total of 10 joints, the first carpometacarpal joint, second and third distal and proximal interphalangeal joints of both the hands were taken into account for the investigations and the values were aggregated.

The photographs were taken under same light conditions, at the same place, at the same time and with the same camera thus reducing the intra-observer variation to less than 0.86.

The mean HOA SCORE is found to be 4.375 with a standard deviation of 1.904 and the mean KL score is 2.150 with a standard deviation of 0.893 and their correlation in scatter plot was found to be statistically significant with a (p value > 0.05), which is similar to the results obtained by Helgi Jonsson et al.⁽³⁾

The mean clinical examination score is 1.450 with a standard deviation of 0.504 and the correlation of its value with that of HOA SCORE in scatter plot was found to be statistically significant (p value < 0.05) which is similar to the result obtained by Helgi Jonsson et al.⁽³⁾

The multiple variable histogram for the mean HOA SCORE, KL score and clinical examination score also showed statistically significant correlation, which is similar to the results obtained by Gudrun P Helgadóttir and Helgi Jonsson et al.⁽³⁾

The mean BMI of 23.475 with a standard deviation of 3.693 showed a uniform rise in the disaggregation chart with HOA SCORE and KL score. However, the graph showed a more uniform rise with the KL score. This is in relevant to the fact that the arthritic findings in photography could be masked due to the presence of excess soft tissues in obese individuals whereas the amount of soft tissues doesn't affect radiographic imaging.

The area under ROC curve is 1, where values above 2.5 showed an increase in the severity of the disease. Thus with a cutoff of 2.5, the sensitivity and specificity of HOA SCORE was 100% for this study. Statistically in an ROC curve, the closer the curve to the left and top margin, the more accurate the test. Here the curve was found to overlapping with the left and top.

The mean value of pain is 1.625 with a standard deviation of 1.055. Women showed increased incidence of pain in all the three joints, whereas men admitted to pain mainly in the first carpo metacarpal joint alone.

This study indicates that the hand photographic score correlates well with that of the radiographic score and clinical examination score as indicated by the results from scattered plot, multiple variable histogram and ROC curve.

VI. Conclusion:

The comprehensively developed HOAScore was made use of in this study. The values obtained through hand photographic score showed a striking similarity as of the values obtained from the radiographic and clinical examination findings, proving to be correlating with the golden standard radiography in assessing and grading hand osteoarthritis. Hand photographic score (HOAScore) can hence be used as an easy alternative method in case of larger groups.

Limitations:

- Small sample size of this study due to the lesser prevalence rate and lesser duration acts as a major limitation factor for this study.
- The values are difficult to interpret in obese patients using the photography method.

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