Pattern of advancement in the zone of calcified cartilage detected in hand osteoarthritis

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Summary

Objective: Using high definition macroradiography the pattern of advancement in the zone of calcified cartilage (termed a ZCC step) was detected in osteoarthritic hand joints of patients and compared to the joint space width (JSW) measurement.

Design: X5 macroradiographs were obtained of the osteoarthritic hands of 44 patients at baseline and at 18 months. The incidence of ZCC steps, identified as an advancement in the mineralized cartilage front into articular cartilage, was assessed at each articular surface. JSW was measured and was used to determine the difference in JSW between hands and groups of joints with and without ZCC steps at both X-ray visits.

Results: ZCC steps were found at the convex articular surfaces in only 42 (48%) hand joints in 28 (64%) patients. Here, ZCC steps were present in 36 joints in the non-dominant hand, compared with 30 joints in the dominant hand. In the former, they were present in 22 DIP, six PIP and eight MCP joints and in 12 DIP, eight PIP and 10 MCP joints in the dominant hand. By 18 months, new ZCC steps had formed in 15 hands with and 17 hands without previous ZCC steps. At both X-ray visits no statistically significant difference in JSW was found between the hands and joint groups with and without ZCC steps.

Conclusion: In patients with ZCC steps, the pattern of distribution in the hand appeared to be related to that due to vascular changes, such as hyperlipidaemia, rather than to that associated with mechanical forces. © 2000 OsteoArthritis Research Society International

Key words: Osteoarthritis, Hand, Calcified cartilage.

Introduction

In osteoarthritic joints, advancement of the zone of calcified cartilage (ZCC) into articular cartilage is observed histologically and at pathology. The increase in the mineralized cartilage front into the body of the articular cartilage contributes to the radiographic appearance of joint space narrowing. It is commonly held that vascular invasion of the calcified cartilage is a critical component in the progression of OA associated with the remodeling of the calcified bed that leads to the advancement of the ZCC. This process has been attributed to two quite different phenomena: either to increased mechanical loading at the articular cartilage junction or to systemic factors. In the former, the calcified cartilage functions as an intermediate stiffness layer between the articular cartilage and the subchondral bone. With advancement in the ZCC, the increase in the undulating structure of its interface with the overlying cartilage and the underlying subchondral bonetransforms shear stresses into tensile and compressive stresses that cartilage is better able to deal with. Alternatively, it is suggested that the stimulus for vascular invasion is a result of lipid-associated intraosseous venous thrombosis, leading to focal bone ischemia followed by repair. Others have suggested that factors such as articular plate compliance and/or altered capillary blood vessel distribution may contribute to the pattern of necrosis in osteoarthritis (OA).

As far as we know, no assessment has been made of the extent of the advancement in the ZCC in osteoarthritic joints of patients. The enhanced spatial resolution of high definition macroradiography has been used to assess their incidence and distribution in osteoarthritic hand joints. Differences in the ZCC between dominant and nondominant extremities were determined, since previously, in the same patient group, we have reported that joint space narrowing (JSN) was symmetrical between extremities and that osteophytosis and subchondral sclerosis were asymmetrical and greater in the dominant extremity.

Patients and methods

Ethical committee approval was obtained from Lewisham and Southwark Health Authority; 44 patients, three men and 41 women, mean (s.o.) age 62 (10) years, mean (s.o.) disease duration 11.6 (10) years were studied. All were selected on the basis of clinical assessment and presence of osteophytes and joint space narrowing on conventional radiography. X5 high definition macroradiographs were taken of both hands of each patient at the beginning of the study and then again 18 months later.

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ASSESSMENTS

The macroradiographs were placed on a backlit digitizer tablet linked to a MOP Videoplan (Zeiss Ltd). A cross-wire cursor was used to measure the minimum joint space width (JSW) in the second to fifth distal and proximal interphalangeal (DIP and PIP, respectively) and metacarpophalangeal (MCP) joints. The detailed description of the method of measurement for this radiographic feature is reported elsewhere. The coefficient of variation for JSW measurement reproducibility was 3.7%.

The incidence of advancement in the ZCC, identified as a step-like increase in the subchondral mineralized zone, was assessed at each articular surface in all joints (Fig. 1). For the purposes of description here, we have called this feature a 'ZCC step'. A count of the presence of this feature at the articular surface of each joint was made. Radiographic progression was determined from the change in incidence at the 18-month visit.

DATA ANALYSIS

The mean and standard deviation (s.o.) of JSW measurements was calculated for the different joints and hand groups with and without ZCC. The Mann–Whitney U-test was used to determine the difference between the joints and these groups. The significance level for all tests was set at P=0.05.

Results

In all but two patients the right hand was dominant. Of all 88 hands, 42 (48%) in 28 (64%) patients had a ZCC step present in the middle of the convex articular surfaces of either MCP and/or at the biconvex surfaces of the DIP and PIP joints. No ZCC step was observed on the concave articular surfaces of these or other joints. In the 42 hands, the ZCC steps were present in 36 joints in the non-dominant hand, compared with 30 in the dominant extremity. In the former, ZCC steps were present in 22 DIP, six PIP and eight MCP joints and in 12 DIP, eight PIP and 10 MCP joints in the dominant hand.

At the 18-month visit the number of joints with a ZCC step had increased. In hands with existing ZCC steps, 15 had a total of 26 new ZCC steps, in 13 DIP, two PIP and three MCP joints in the non-dominant, and five DIP, two PIP and one MCP joints in the dominant extremity, respectively. Seventeen hands with no ZCC steps at baseline had 24 new ZCC steps, in 11 DIP and three PIP joints in the non-dominant, and eight DIP and two PIP joints in the dominant hand, respectively. Although ZCC steps appeared preferentially in the non-dominant hands, there was no statistically significant difference in their distribution.

No statistically significant difference in mean total minimum JSW was found between the 42 hands [mean (s.o.) 12.9 (5.3) mm] with, and the 46 hands [14.1 (7.2) mm] without ZCC steps. Further, in the hands with ZCC steps there was (1) no significant difference in mean total minimum JSW between those joints with and without ZCC steps; (2) JSN was similar and not statistically different between dominant and non-dominant PIP, DIP and MCP joints; (3) no statistically significant difference was detected between any of these categories at the 18-month visit. Mean (s.o.) JSW was significantly narrower in the DIP 3.48 (1.25) mm, P<0.006 than in the PIP 3.71 (1.46) mm which was significantly narrower P<0.0001 than in the MCP joints 5.17 (2.99) mm.

Discussion

Within the subset of patients studied who had a ZCC step, approximately half the hands had exhibited this feature, which was observed at the joint's central convex articular surfaces. Detection of such a feature at this
The advancement in the ZCC attributed to increased stresses within the articular cartilage that could contribute to its derangement and subsequent damage. Thus, it would appear that the study findings lead one to consider that systemic factors, such as hyperlipidemia or the effects of obesity, may be responsible for the advancement in the ZCC. Further studies are required to determine their respective roles in OA. In this instance, it would be helpful for patients to be stratified into those with and without these conditions in order to determine their respective contribution to the advancement in the ZCC. Such an investigation would require the use of macroangiography, since the depth of the ZCC advancement into cartilage was ≤0.2 mm, which is at or below the spatial resolution of features detected by standard radiography.

References