VI. SUMMARY
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In the present study radiological and ancillary investigations to elucidate the causation of bone changes, were undertaken in 54 lepromatous and 164 tuberculoid leprosy patients.

The overall incidence of various forms of bone and/or joint changes observed was 61% in lepromatous and 49% in tuberculoid patients. The joint changes with or without contractions showed an incidence of 37.3% in tuberculoid.

In the lepromatous type, such changes as bone cyst formation (7.4%), and honey combing (14.8%), subarticular bone erosion (29.6%), expanded cortex (18.5%) and osteoporosis (18.4%) appeared to be specific. Other changes noted were some expansion of the shaft and enlarged nutrient foramina.

In the tuberculoid type, tuft erosion in the form of nicks, slices and disappearance of the terminal phalanx in longitudinal axis were observed in 38.3%. These were due to trophic and/or vascular changes and apparently of similar appearance as seen in scleroderma, psoriasis etc. Concentric absorption following hazy reaction with subperiosteal bone involvement was seen in phalanges and metatarsals. This was associated with cupping of joint surface and apparent increase in density; erosion of articular ends was seen in 30.8% in patients with soft tissue swelling and ulceration.
Sub-periosteal bone formation was depressed but there was compensatory activity of the medullary side of the cortex. The shaft looked like a 'sharpened pencil' or 'dagger' and the joints like 'pin and cup' instead of 'ball and socket'. Such findings have been known to occur in infections other than leprosy. Saucer joints in the small joints of the hands and feet were seen in 11.2% of cases; the sockets receiving the ball being 'saucer shaped'. The joint space was not lost and there was no evidence of any bone erosion. The picture of chronic osteomyelitis with sub-periosteal new bone formation or calcification (14.0%), the calcification being comparable to myositis ossificans, probably resulting from organised blood clot due to mild trauma.

Relation of bone affection to the presence of *M. lepra* has been studied by bone biopsy in 15 lepromatous and 35 tuberculoid cases with or without bone affection clinically and radiologically. Lepromatous cases with bone involvement showed the presence of acid-fast bacilli in all and also in two others without bone involvement. Biopsy from 2 of the tuberculoid cases with bone involvement showed the presence of *M. lepra*. Of the 4 areas (the sternum, ilium, upper end of tibia and calcaneum) the calcaneum was most commonly affected by *M. lepra*. Bone specimens in 4 lepromatous and 9 tuberculoid cases were studied histopathologically these included 4 sequestra and 9 bony fragments in the process of absorption and destruction. The changes seen were complete disorganisation with loss of
continuity of the cortex, osteoclastic activity and chronic inflammatory cells infiltration and myxomatous changes in a few (lepromatous) cases.

Biochemical investigations were done in 5 lepromatous, 5 tuberculoid cases with and without bone changes and 3 volunteers to observe whether metabolic disturbances were responsible for any bony changes. It appeared from these investigations that the serum calcium, alkaline phosphatase and inorganic phosphorus were within normal limit.

Nerve involvement was present in 16 lepromatous cases out of 54 and 106 tuberculoid cases out of 164. The nerves of the superior extremity were involved on 130 occasions whereas those of the inferior extremity were involved in 202 occasions. Ulcers were present in the inferior extremity in 34.8% and in the superior extremity in 10%. The ulnar nerve was involved in 75.4% and the musculocutaneous nerve in 52.4%.

Experiments were undertaken to produce trophic ulcers in the foot or bone change after crushing the sciatic nerve in rabbits. However, the results were inconclusive.

In a group of 54 lepromatous leprosy, 16 had nerve involvement, 6 had ulceration, 6 had both ulceration and nerve involvement and 27 had bone involvement. Those with bone changes showed nerve affection alone in 12, ulceration and 4 and both in 3. In the tuberculoid series (164 cases), 106 had nerve involvements, 92 had ulceration (78 had both nerve affection and ulceration), 107 had bone involvement. Those with bone changes
showed nerve affection alone in 82, ulceration in 71, and both these features in 63. Higher incidence of bone changes in patients showing nerve involvement and ulceration was thus observed.

Histopathology of nerve were carried out in 5 cases (2 lepromatous and 3 tuberculoid). In all 3 tuberculoid and 1 lepromatous cases there were perineural and endoneural infiltration of the lepra bacilli. M. leprae were found more in number in the lepromatous cases than the tuberculoid variety. Areas of caseation were observed in the nerve specimen, which were obtained from tuberculoid patients.

Bone changes in leprosy were usually seen in association with deep old ulcers but not with superficial recent ulcers. Ulcers on the sole in lepromatous leprosy were less common (11.1%). The relationship between the ulcers and force acting on the foot during walking seemed very important in the causation of bone changes. Plantar ulcers only occurred on the walking anaesthetic feet probably due to unnoticed repeated minor trauma. It appeared that infection spread through plantar fascia or tendon sheath and affected the bone. In patients with foot drop walking with high stepping gait, ulcers occurred at the head and the base of the metatarsals.

The present observations strongly suggest that nerve affection and ulcer formation favouring secondary infection are the two very important factors for the production of bone changes. Mechanical trauma also plays an important role in the causation of ulcers.
Arteriography was done in 6 tuberculoid, 5 lepromatous cases and in 3 healthy control. This showed stasis in 4 (3 tuberculoid and 1 lepromatous) and endarteritis obliterans with corkscrew appearance in one lepromatous patient with absorption of terminal phalanx. Venography was done in 22 tuberculoid cases and in 3 controls; but no sign of thrombophlebitis or venous obstruction could be observed.

To investigate the role of lymphatics contributing indirectly towards the production of bone changes, lymphangiography was done in 6 lepromatous and 5 tuberculoid patients. No obstruction, or collateral circulation or dilatation was, however, observed. The channels practically looked normal in the radiography.

Histopathology of blood vessels were carried out in 21 specimens, of these 5 were lepromatous and 16 tuberculoid. M. leprae were found in 11 cases, of which 4 were lepromatous and 7 tuberculoid patients.

The chronological events leading to the bone changes in leprosy appeared to be as follows. With nerve involvement there is anaesthesia and trophic changes in the muscles in oldstanding cases. Vascular stasis and impaired circulation results from affection of blood vessels. Whether the lymphatics play any role is not quite clear. Subsequently, the traumatic factor including friction, operates leading to cracks, blisters and haematomata. Ulcers develop at the pressure points. The ulcers then get secondarily infected and infection burrows into the soft tissue and produce abscesses, involving ultimately, the bones and joints.
The bone involvement is commonly observed in tuberculoid cases where the above factors work often in combination. In lepromatous cases, the bone changes are less frequent but may be more due to the infection with the specific bacilli rather than due to the other factors. The bacilli lodge either in the medulla of the small bones of hands and feet and then articular ends. There is acute inflammation with soft tissue swelling known as the 'explosion'. There is formation of bone cyst in the medulla producing 'lepromatous multiplex cystica' simulating 'tuberculous multiplex cystica'. In joints, the articular margins are lost with disintegration of joint space and there is often subluxation of the joint to the extent of one end being telescoped on the other.

X-ray appearance in the lungs of 128 leprosy patients (46 lepromatous and 82 tuberculoid) done in the present study simulated tubercular lesions in 13% of lepromatous and 3.6% of tuberculoid cases. Allergic pneumonitis clearing within 15 days recorded in 6.5% of lepromatous and 0.8% in tuberculoid patients.

Out of 18 leprosy cases (6 lepromatous and 12 tuberculoid) 5 (2 lepromatous and 3 tuberculoid) showed abnormal radiological signs in the lung fields. Two of these cases, 1 of each variety showed acid fast bacilli in the sputum.

An experimental study was undertaken to induce leprosy and tuberculosis by instillation of sputum from lepromatous leprosy and pulmonary tuberculosis patients where acid fast bacilli were positive into the bronchi of guineapigs. This succeeded in producing tuberculosis confirmed by histology. Pulmonary leprosy as an entity could not be established.