

ORIGIN OF METAPLASTIC CARTILAGE IN SKIN ARTHROPLASTY

By

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When the mesenchymal cells become differentiated into different types of connective tissue some of the cells remain at a less differentiated stage. Thus connective tissue always contains a host of multipotent connective tissue cells which may undergo metaplastic development into a new type of connective tissue (*Maximow* 1926, 1927, *Ham* 1953). Both experimental studies and clinical observations have shown that cartilaginous metaplasia occurs in the connective tissue used as interposition material in skin arthroplasties (*Kettunen* 1958, 1959). Connective tissue growing from a freshened articular surface and the connective tissue of the skin graft are subjected to pressure and function of the joint. Multipotent connective tissue cells then undergo metaplastic development into cartilage.

The origin of the cells undergoing metaplastic development is a very interesting problem. It may be assumed that the cells derive from both granulation tissue growing from freshened joint surface and from the connective tissue of the skin graft, i.e. the granulation tissue and the transplants both take an active part in the formation of new metaplastic cartilage. It may also be assumed that metaplastic cells derive from granulation tissue and that the connective tissue of the skin graft functions merely as the culture medium for granulation tissue undergoing metaplasia and as interposition material protecting it against the pressure exerted by the joint (*Kettunen* 1958).

The purpose of the present investigation is to study the origin of

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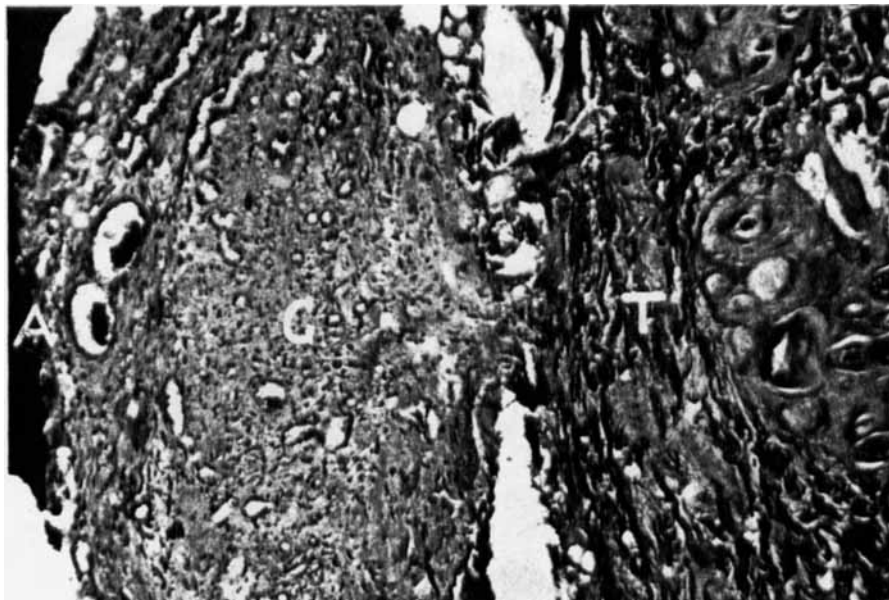


Fig. 1.

The preparation 2 weeks postoperatively. Left, surface of the acetabulum from which articular cartilage has been removed (A). In the middle, granulation tissue (G) that has grown from the bone surface and, right, degenerating homoplastic skin graft (T).
× 80.

metaplastic cartilage by using fresh homoplastic skin graft instead of fresh autogenous skin graft as interposition material in skin arthroplasties in the hip joint of cats. It is known that a homoplastic graft is always destroyed (*Peer* 1955). If homoplastic tissue is employed as interposition material, it is possible to eliminate the multipotent connective tissue cells of the autogenous graft that might participate in the formation of new articular cartilage. The results thus obtained have been compared with those of earlier experiments using autogenous interposition material to find out the role of granulation tissue growing from the articular surface and the part played by the connective tissue of a skin graft in the formation of new metaplastic articular cartilage.

MATERIAL AND METHODS

A total of ten adult cats was used for the experiments. The operation technique was the same as in the previous experiments (*Kettunen*

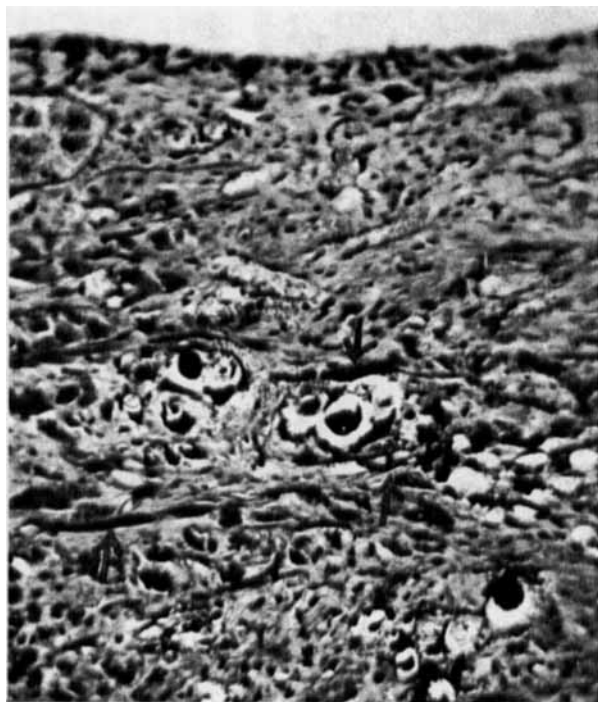


Fig. 2.

The preparation 6 weeks postoperatively. New connective tissue growing from the bone surface has replaced almost completely the degenerating homoplastic connective tissue. In the middle, remains of degenerative collagenous bundles (arrow). At the top, articular surface. $\times 160$.

1958). The hip joint was opened up, the cartilage of the acetabulum removed and a skin graft taken from another cat was placed on the freshened joint surface. The animals were sacrificed 2, 3, 4, 5, 6, 7, 8, 10, 12 and 14 weeks after the operation. The acetabulum was now detached completely, fixed in 10 per cent neutral formalin, decalcified in 5 per cent trichloroacetic acid and the preparations were stained by the Weigert-van Giessen method (*Romeis 1948*).

MACROSCOPIC OBSERVATIONS

During the first month of observation the transplant was visible to the naked eye. In some of the cases the graft was destroyed in the weight-bearing area of the joint and the articular surface consisted of bare bone. It was no longer possible during the second month of obser-

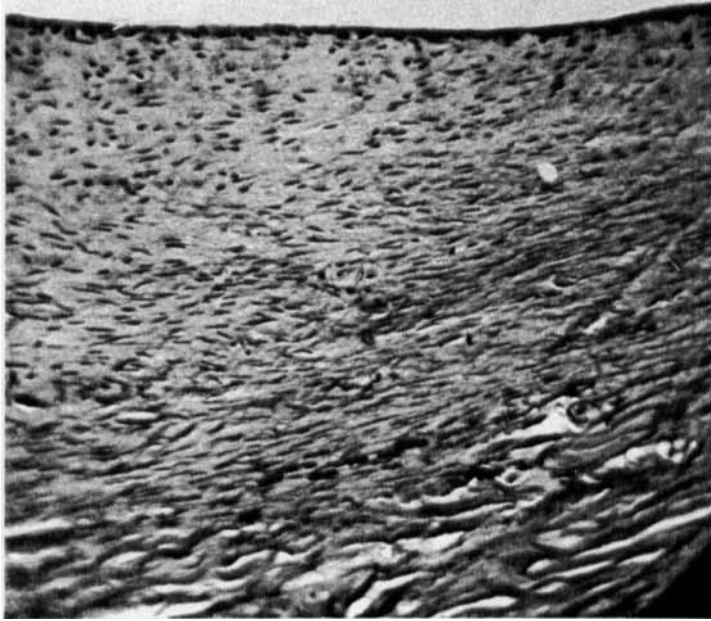


Fig. 3.

The preparation 12 weeks postoperatively. The ground substance of the connective tissue nearest the articular surface has increased and contains slightly differentiated connective tissue cells. Deeper down, there is dense fibrous connective tissue. At the top, the articular surface. $\times 100$.

vation to discern the skin graft macroscopically. The articular surface was covered by a layer of connective tissue which was destroyed in a part of the preparations in the weight-bearing area. There were no signs of cartilaginous metaplasia. The situation remained roughly unchanged during the third month. Incipient cartilaginous metaplasia was established in a preparation taken 14 weeks postoperatively. A part of the connective tissue covering the joint surface in the weight-bearing area of the joint resembled fibrous cartilage.

MICROSCOPIC OBSERVATIONS

Pronounced signs of degeneration were observed in the epidermis and dermis of the skin graft during the first month of observation. New connective tissue grew from the joint surface from which the articular cartilage had been removed. This new tissue penetrated here and there into the connective tissue of the degenerating skin graft. Foci of

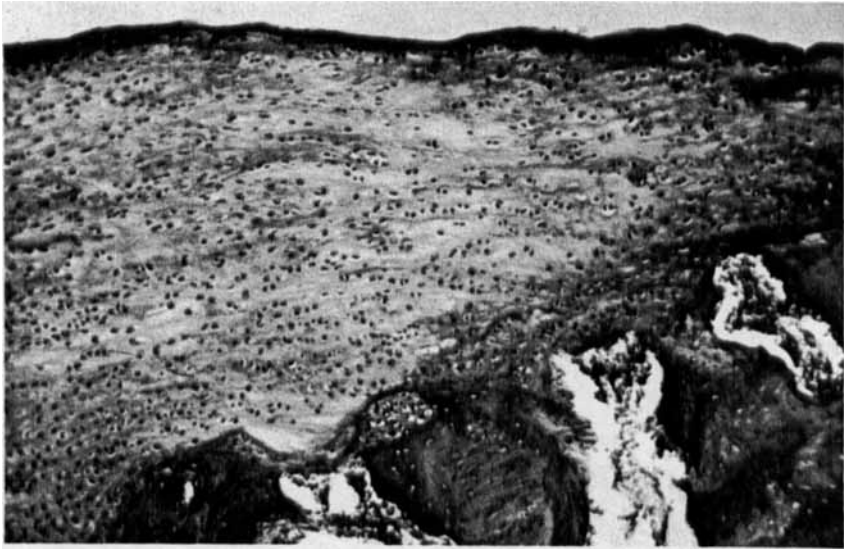


Fig. 4.

The preparation 14 weeks postoperatively. Metaplastic fibrous articular cartilage.
× 80.

inflammatory cells occurred, especially at the margin of the graft and the granulation tissue (Fig. 1).

During the second month the granulation tissue growing from the bone surface replaced the connective tissue of the gradually degenerating graft. The collagenous bundles of the skin underwent a fragmentation process and broke up, and at the end of the second month (Fig. 2) all that was left was remains of the collagenous bundles surrounded by new connective tissue.

The preparations of the third month showed on the joint surface fibrous connective tissue in which the collagenous fibres, especially in the weight-bearing area of the joint, were arranged parallel to the articular surfaces. The connective tissue growing from the bone surface had replaced the connective tissue of the skin graft.

A preparation obtained 12 weeks postoperatively revealed increase in the ground substance of the connective tissue and slightly differentiated connective tissue cells in the ground substance. These changes began in the connective tissue from the direction of the joint surface. It was not possible during the first three months to demonstrate actual metaplastic cartilage (Fig. 3).

Preparations which were obtained 14 weeks postoperatively displayed

the first distinct cartilaginous metaplasia of the connective tissue. The metaplastic cartilage was fibrous and lay in the weight-bearing area of the joint. Elsewhere the joint surface was covered by fibrous connective tissue (Fig. 4).

DISCUSSION

Destruction of the interposition material in the weight-bearing area of the joint in the homoplastic series was found to be more frequent than in an earlier experimental series in which autogenous connective tissue was employed as interposition material. The homotransplant, which is condemned to die, is not able to protect the granulation tissue against pressure exerted by the joint as well as autogenous interposition material. It must be stated, on the other hand, that in the homoplastic series more of the connective tissue used as interposition material was preserved than in the earlier control series in which no interposition material was employed and in which articular pressure destroyed almost completely the granulation tissue growing from the bone surface.

Preparations, especially those made in the second month, showed vigorous infiltrative growth of the granulation tissue into the degenerating skin graft. The cells of the granulation tissue deriving from the bone marrow are but little differentiated and have a marked proliferative ability. Their metaplastic capacity, too, is obviously fairly pronounced. It is indeed probable that granulation tissue has an important role in the metaplastic development of cartilage. The freshening of the joint surface as used in Kallio's skin arthroplasties (Kallio 1956) is therefore most important since it is a precondition for the formation of granulation tissue capable of metaplastic development.

It was established both macroscopically and microscopically that cartilaginous metaplasia began at a later phase and more weakly in the homoplastic series than when autogenous material was used. The first cartilaginous metaplasia in the homoplastic series was observed 3½ months postoperatively, while with autogenous material distinct cartilaginous metaplasia occurred within 2½ months. Cartilaginous metaplasia was also weaker in the homoplastic series. It was found both in earlier experiments and in the present series that cartilaginous metaplasia in the connective tissue begins from the articular surface. When an autogenous skin graft is used as interposition material the subcutaneous tissue, which according to Maximov is relatively little differentiated and contains multipotent connective tissue cells, is subjected

immediately after surgery to articular pressure causing metaplasia. If, again, homoplastic connective tissue is used as interposition material the multipotent connective tissue cells of the granulation tissue must grow through the degenerating transplant to the joint surface in which the metaplasia begins. In my opinion this observation, i.e. the weakening and retardation of cartilaginous metaplasia when homoplastic connective tissue is used as interposition material, lends support to the view that autogenous connective tissue graft participates actively in the formation of new metaplastic cartilage of the joint.

For clinical skin arthroplasties, the following important conclusions can be drawn:

- granulation tissue deriving from bone marrow and growing from articular surface freshened in connection with skin arthroplasties plays an important role in the formation of new metaplastic articular cartilage. It is consequently necessary in clinical skin arthroplasty to perform the freshening of the articular surface with great care in order to produce the best possible conditions for the formation of vigorous connective tissue capable of metaplasia,
- fresh autogenous skin graft used as interposition material protects granulation tissue capable of metaplasia against articular pressure,
- the multipotent connective tissue cells of the autogenous skin graft participate actively in the formation of new joint cartilage.

S U M M A R Y

The origin of metaplastic articular cartilage originating in skin arthroplasties was studied using fresh homoplastic skin transplant as interposition material in arthroplasties in the hip joint of cats. The results obtained were compared with authors' previous experimental investigations in which fresh autogenous skin graft was used as interposition material in arthroplasties. The new connective tissue growing from freshened articular surface was found to be important for the formation of metaplastic joint cartilage. The freshening of the articular surface in skin arthroplasties is a precondition for the formation of vigorous granulation tissue capable of a metaplastic process and it must therefore be performed with great care. The role of the autogenous skin graft used as interposition material is protection of the connective tissue growing from the surface of the bone against articular pressure and the multipotent connective tissue cells of the skin transplant take an active part in the formation of new articular cartilage.

RESUME

L'origine du cartilage articulaire métaplastique provenant d'arthroplasties de peau a été étudiée en utilisant une transplantation homoplastique de peau comme matériel d'interposition dans les arthroplasties de l'articulation de la hanche chez les chats. Le résultat obtenu a été comparé aux recherches expérimentales effectuées antérieurement par l'auteur dans lesquelles des greffes autogènes fraîches de peau avaient été utilisées comme matériel d'interposition dans les arthroplasties. On a constaté que le nouveau tissu conjonctif qui s'est formé à partir de la surface articulaire reconstruite était important pour la formation du cartilage articulaire métaplastique. La réfection de la surface articulaire dans les arthroplasties de peau est la première condition à la formation d'un tissu de granulation vigoureux capable de processus métaplastique et doit être effectuée avec beaucoup de soin. Le rôle de la greffe autogène de peau utilisée comme matériel d'interposition est de protéger le tissu conjonctif qui se forme de la surface de l'os contre la pression articulaire et les cellules multipotentes du tissu conjonctif de la greffe épidermique prennent une part active à la formation du nouveau cartilage articulaire.

ZUSAMMENFASSUNG

Die Entstehung von metaplastischem Gelenksknorpel in ursprünglichen Hautarthroplastiken wurde untersucht indem man frische homoplastische Hauttransplantate als Interpositionsmaterial bei Arthroplastiken des Hüftgelenkes von Katzen benützte. Die erhaltenen Ergebnisse wurden mit vorhergehenden experimentellen Untersuchungen des Verfassers verglichen, in denen frische autogene Hauttransplantate als Interpositionsmaterial bei Gelenksplastiken verwendet worden waren. Das neue, von angefrischten Gelenksoberflächen wachsende Bindegewebe wurde als wichtig für die Bildung von metaplastischem Gelenksknorpel befunden. Die Anfrischung der Gelenksoberfläche bei Hautarthroplastiken ist eine Vorbedingung für die Bildung eines kräftigen Granulationsgewebes, das zur Metaplasie fähig ist, und sie muss daher mit grosser Vorsicht ausgeführt werden. Die Rolle des autogenen, als Interpositionsmaterial verwendeten Hauttransplantates, besteht in der Beschützung des von der Knochenoberfläche gegen den Gelenksdruck wachsenden Bindegewebes, und die multipotenten Bindegewebszellen des Hauttransplantates nehmen aktiv teil an der Bildung des neuen Gelenksknorpels.

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