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Experience with Intraoral Resection and Immediate Reconstruction in Cases of Radio-Osteomyelitis of the Mandible

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Summary

In general, in cases of radio-osteomyelitis the affected mandibular segment is resected and a secondary reconstruction carried out at a later date whenever one considers a reconstruction at all. We have resected subperiosteally and immediately reconstructed, via the oral route, parts of the mandible in 10 cases of radio-osteomyelitis. We were induced to do so by the good results of resection and immediate reconstruction of parts of the mandible in cases of ordinary osteomyelitis. In 7 out of 10 cases the graft took in the first instance. In 3 cases the graft was lost. 2 out of the 7 successful cases showed no postoperative complications. In the other 5 cases, there were 3 dehiscences; one of them was closed by secondary suturing. And in the remaining 2 cases we had a partial necrosis of the covering mucosa. In all those 5 cases, in which the bone was partially exposed 8–13 days after the operation, the bone grafts took, but longer postoperative treatment was necessary. This treatment consisted in the covering of the exposed bone by vaselinized iodoform gauze until secondary epithelialization occurred over granulation tissue. The problems arising from resection and immediate reconstruction in radio-osteomyelitis are discussed. The quality of the soft tissues in the operative area is, in our opinion, mainly responsible for the postoperative course with or without complications. The preoperative bacterial infection is, according to our experience, not relevant to the success of bone transplantation in these cases.

Key-Words: Radio-Osteomyelitis of the mandible: Bone transplantation; Immediate reconstruction of radio-osteomyelitis mandible.

Introduction

There are distinct differences between radio-osteomyelitis and common osteomyelitis of the mandible as far as the clinical course and prognosis are concerned. The reason for this has to be seen in an altered response of bone and soft tissues. This depends as much on the radiation damage of the different structures of the osteogenic and myelogenic matrix of the bone as on the damage to the vascular and connective tissues of the bone and surrounding soft tissues. The radiotoxic damage to the cellular and vascular elements of the bone and surrounding soft tissues causes a reduction of the anti-inflammatory and reparative mechanisms; infection – once superimposed on the radio-damaged bone – leads to a vicious circle with progressive necrosis of the hard and soft tissues. Early healing or elimination of the affected parts of the mandible is therefore necessary in order to prevent further extension of the radio-osteomyelitis and the breakdown of the overlying soft tissues.

For treatment of ordinary mandibular osteomyelitis, we have performed resection and simultaneous reconstruction via an oral approach with good results *(Obwegeser* 1960, *Obwegeser* and *Sailer* 1978). Therefore, we have utilized the same method in cases of mandibular radio-osteomyelitis *(Obwegeser* 1965, 1966). The experience with this approach is presented in this paper and the problems involved are discussed.

Clinical Material

In 10 patients resection and immediate reconstruction of a wider portion of the mandible was performed on account of radio-osteomyelitis. Their average age was 50, the youngest being 30, the oldest 68. There were 3 females and 7 males. In 6 cases, the primary disease had been carcinoma of the tongue, mandible or floor of the mouth, and one case each of pleomorphic adenoma of the palate, lymphangioma of the tongue, ameloblastoma of the mandibular ramus and one mandibular tumour of unknown aetiology *(Tab. 1)*. The time interval from radiotherapy to onset of radio-osteomyelitis was on average six years, the shortest interval being 4 months, the longest 18 years.

In 5 out of the 10 patients, spontaneous fractures had occurred. In 3 cases, decortication had already failed to cure the radio-osteomyelitis. All

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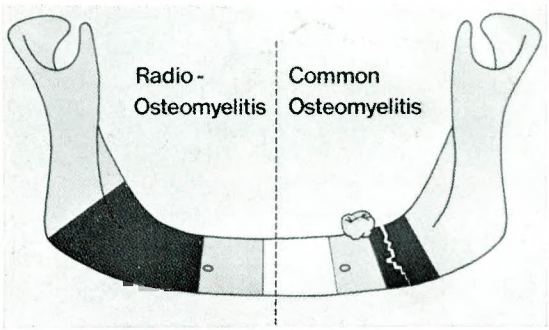


Fig. 1 Extent of resection in cases of radio-osteomyelitis and osteomyelitis of other causes. The black area demonstrates the smallest amount of resection, the grey area the largest amount.

Table 1 Primary disease preceeding radio-osteomyelitis of the mandible.

	Number of patients
Ameloblastoma	1
Carcinoma of tonsils	1
Carcinoma of larynx	1
Pleomorphic adenoma of parotid	1
Carcinoma of mandible	2
Carcinoma of submandibular gland	1
Carcinoma of floor of mouth	1
Lymphangioma of tongue	1
Tumour of unknown aetiology	1
Total	10

cases presented fistulae or exposed necrotic bone. Radiologically, the extent of the radio-osteomyelitis could not be assessed, not even in the presence of pseudo-sequestration and imminent spontaneous fracture.

Extent of Resection and Technique of Reconstruction

The technical principles for the resection and immediate reconstruction in cases of osteomyelitis of the mandible *Obwegeser* 1960, 1963, 1966) are also applicable to radio-osteomyelitis. The extent of resection is shown in *Fig. 1* compared with that in ordinary osteomyelitis *Obwegeser* and *Sailer* 1978). The largest defect created was 13 cm, the smallest about 5 cm, and the average length resected was 9 cm against 6 cm in ordinary osteomyelitis. The extent of the clinically affected part was on average less than about 4 cm, but the part which had to be removed measured more than double that, i.e. 9 cm on average. In 3 patients, iliac crest was used for reconstruction and in 7, ribs. In 5 patients a disarticulation had to be performed.

The resection and reconstruction were performed via the oral approach. Only in 2 cases with pre-



Fig. 2a



Fig. 2b

Fig. 2a–f
Resection and immediate reconstruction via the oral route in a case of radio-osteomyelitis of the ramus with a spontaneous fracture. Pus had been flowing into the oral cavity via a large opening.

Fig. 2a
Frontal view before surgery. Note swelling of the right cheek with subcutaneous abscesses.

Fig. 2b
Patient 1 year after operation.

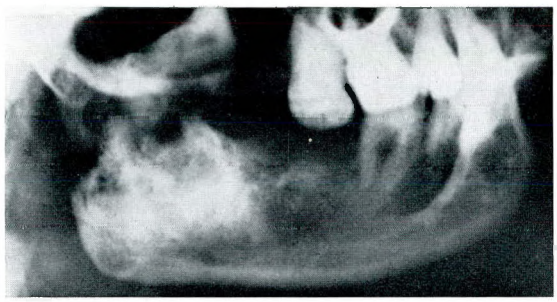


Fig. 2c

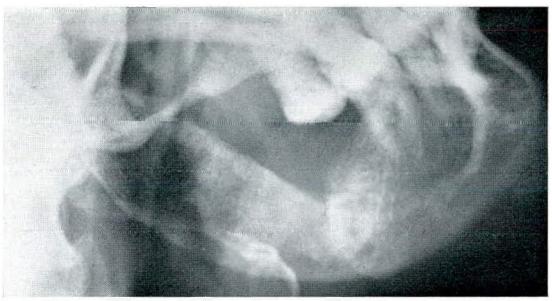


Fig. 2d

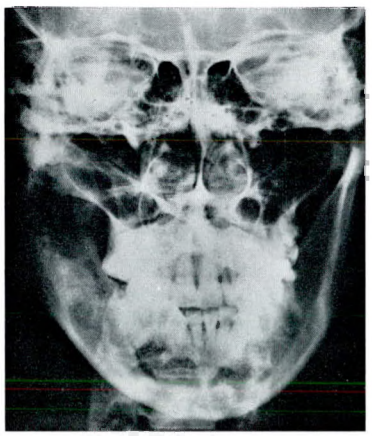


Fig. 2e

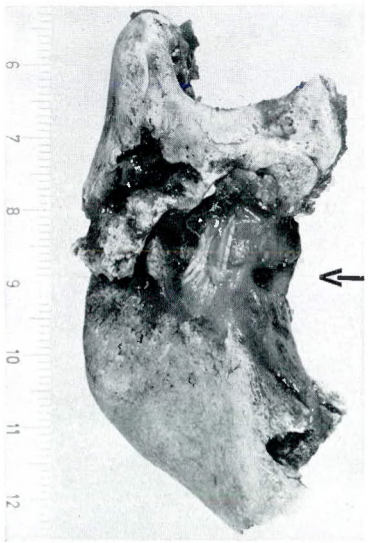


Fig. 2f

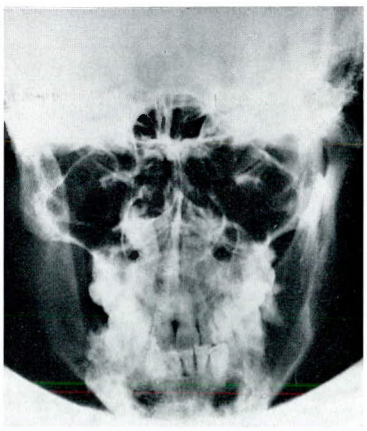


Fig. 2g

Fig. 2c–f c + e) Preoperative p. a. and lateral projection of affected mandible. d + g) P. a. and lateral projection of mandible 6 months after surgery. f) Resected specimen of the entire ramus and angle of the mandible demonstrating radio-osteomyelitis with a spontaneous fracture. The arrow indicates a large sinus from which pus had been discharging into the oral cavity.

operative skin problems, was an additional external incision necessary for soft tissue flap rotation in order to close skin defects or to replace badly radio-damaged skin by soft tissues of adequate quality. Discharging fistulae were not specifically excised or dealt with. Access to the mandible was obtained by a vestibular incision through existing mucosal defects. The incision passes along the gingival sulcus, and in edentulous areas, it is made about 3–5 mm labial to the alveolar crest.

As in cases of ordinary osteomyelitis, in radio-osteomyelitis the periosteum is scarcely adherent to the involved bone. While in ordinary osteomyelitis cases the periosteum is firmly attached to the mandible beyond the osteomyelitic area, this is not the case in radio-osteomyelitis of the mandible. Due to the radio-damage to the bone and surrounding soft tissues, the periosteum peels off the mandibular cortical plate with ease, not only in the extent of the radio-osteomyelitis, but also in areas of radio-damaged bone to where the bone infection has not yet progressed. The closer the periosteal elevation approaches areas of better blood supply, the more adherent the periosteum to the mandibular cortex. Although this is a general finding, it does not indicate clearly enough where to resect the mandible. In order to determine the correct distance of the resection line

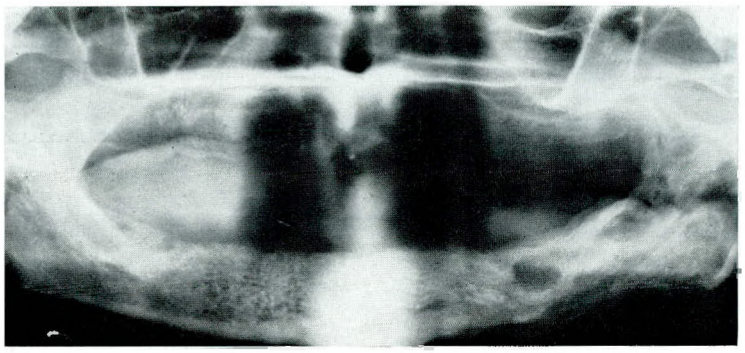


Fig. 3a

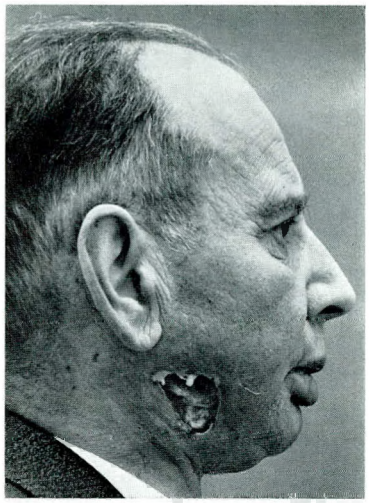


Fig. 3b

Fig. 3a + b Radiological appearance of radio-osteomyelitis and severe radio-damage in a mandible 20 years after bilateral irradiation with 6000 rads. a) X-ray showing radio-osteomyelitis on the left side 20 years after radio-therapy. The right side appears radiographically almost normal in spite of severe radio-damage. Clinically the left mandibular alveolus was denuded and suppurative. The left side was exquisitely painful. On the right side, there was no clinical symptomatology. b) The same case: 17 months later the right side showed radio-osteomyelitis with suppuration and breakdown of the soft tissues of the cheek.



Fig. 4 Progressive break-down of the outer tissues in a case of radio-necrosis, starting months after radiotherapy. There is almost no suppuration, in contrast to the case of Fig. 3b, which started 20 years after irradiation.



Fig. 5 A case of radio-osteonecrosis of the mandible without suppuration or spontaneous fracture in spite of complete breakdown of surrounding soft tissues. The entire horseshoe of the mandible is almost completely exposed (from Obwegeser 1962).

from the osteomyelitic focus *(Obwegeser* 1962), vertical bone cuts using a Lindemann bur, were made into the buccal cortex beginning adjacent to the macroscopically affected part and continued at intervals of 0.5 to 1.0 cm on both sides of the affected area *(Fig. 6)*. The resection was performed subperiosteally and it was completed in the nearest osteomyelitis-free area in which adequate bleeding from the bone marrow occurred. This included the resection of non-infected but radio-damaged bone.

The reconstruction of rather large defects was performed in all cases as an onlay or inlay technique procedure whether iliac crest or rib was used. Costo-chondral grafts were used for the reconstruction of the ramus when disarticulation was necessary. Partial decortication of the graft, extensive decortication of the recipient mandibular area, avoiding dead space, accurate adaptation of the soft tissues to the graft by circumferential or perfacial sutures, careful two-layer-eversion-closure of the mucosal wound edges and other obvious principles of oral bone grafting to mandibular defects were observed. Firm direct bone wiring, but not plates were used to fix the graft to the remaining mandible and a mush of cancellous bone was interposed (*Hopusch* 1947). One or two Haemovac drains were inserted, but vacuum for drainage was only applied every 6 to 12 hours for 2 to 3 minutes since constant vacuum leads to aspiration of oral fluids even along the sutures. Whenever possible intermaxillary fixation is applied for 6 weeks.

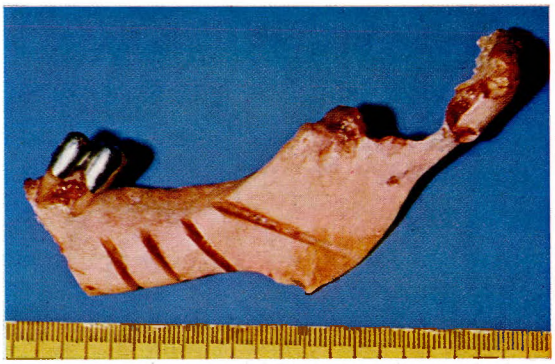


Fig. 6 Vertical cuts through the buccal cortex of the mandible in order to determine the necessary extent of resection.



Fig. 7 Large part of the right mandible in a case of radio-osteomyelitis with the sequestrum apparent after intravenous vital staining (disulphine blue) during operation. Note that only the sequestrum does not stain. Radio-damaged bone shows slight staining; inflammatory granulation tissue around sequestrum shows intensive staining.

Results

In 7 out of 10 patients, bony union was obtained *(Tab. 2)*. In two of the seven successful cases, the postoperative course was uneventful *(Fig. 2)*; in the other five cases some problems occurred, and success was achieved only because of experience in handling problems in reconstructing mandibular defects. In 2 of the remaining 5 successful cases, the overlying oral mucosa became necrotic to the extent that about half of the occlusal aspect of the graft was exposed between the 8th and 11th day after operation. The lingual and buccal soft tissues remained otherwise adherent to the graft. This is an important sign that the graft has the necessary prerequisites for survival.

Table 2 Results of intraoral resection and immediate reconstruction of the mandible in cases of radio-osteomyelitis.

	Number of patients
Immediate reconstruction, successful	7
Immediate reconstruction, unsuccessful	3
Total	10

The treatment involved only the covering of the area in question with vaselinized iodoform gauze kept in place by a simple template. Initially, at weekly intervals, the gauze was changed and the area carefully cleaned; on several occasions, su-

perficial small necrotic bone spicules were removed. Applying this simple treatment of covering the free bone with vaselinized iodoform gauze, secondary epithelialisation was achieved within 5 and 9 months, respectively.

In the 3 other patients of the 5 mentioned above, wound dehiscence occurred on the 5th a date is missing here, 13th day after operation. The case with dehiscence on the 5th day was treated by revision and resuturing without further complication. In the remaining two cases, resuturing was not attempted. The area in question was rinsed with Neomycin solution and protected by vaselinized gauze as in the two previously mentioned cases in which the overlying oral mucosa had become necrotic.

We definitely lost 3 grafts whereas in the 7 cases described the grafts took and have fulfilled their function for 2 to 13 years to date. In one of the three cases which failed, decortication was performed 4 months prior to resection and immediate reconstruction. Even after this intervention, wound dehiscence occurred on the 4th postoperative day, indicating the poor condition of the soft tissues. 1 year after removal of the graft, a further attempt was made to reconstruct the missing part of the mandible. Again, dehiscence followed the operation and necrosis of the cheek, measuring 4 × 8 mm, occurred 4 weeks postoperatively. The graft was removed. 7 weeks later after local infection had settled, the irradiated area of skin of the cheek and neck was excised and replaced by a large rotation flap in which superficial necrosis took place and which healed spontaneously. 2 years after soft tissue replacement, yet another reconstruction of the mandible was tried because the patient insisted. Dehiscence occurred again and the graft could not be saved; it was removed six weeks postoperatively. In the two other cases, reconstruction has not been reattempted.

Discussion

In ordinary acute mandibular osteomyelitis the spread of the process is arrested by the formation of a defensive barrier in the bone. This defensive barrier can be observed in the X-ray as sclerosis approximately 2–3 months after the osteomyelitic process has started. It is comparable to the abscess wall formation in the soft tissues. Without treatment a chronic suppurative process remains within these limits, a condition which can lead to the formation of sequestrae. After a symptomless period, swelling, fistulae and pain may recommence. Such a secondary chronic osteomyelitis can last for many years, sometimes, 10, 20 or 30 years without considerable damage to the soft tissues. Endosseous or periosteal bone formation in the area of this secondary chronic osteomyelitis are the response of osteoplastic tissue to chronic infection.

The behaviour of primary chronic osteomyelitis of the mandible is similar, but is however free from abscess and fistula formation. Swelling and pain appear and disappear as symptoms and signs of marrow infection. In the X-ray, the sclerosis of the marrow is the visible response of the osteoplastic matrix to the inflammatory irritation. This process also never leads to breakdown of the soft tissues.

Irradiation of the mandible can cause serious damage or even death of the cells of the osteogenic matrix. The reduction of the lumen of the arterioles by thickening of the intima leads to a reduction of the blood supply of the bone and the surrounding soft tissues, whose connective and epithelial tissues are also extensively affected. It seems as if the bone dies more or less without reaction. In the X-ray, one can hardly distinguish such a mandible from a healthy one *(Fig. 3.* Radio-osteomyelitis only develops once the bone damaged by irradiation becomes infected. The part of the mandible damaged by irradiation displays no capacity to limit the process of infection as in the case of ordinary osteomyelitis. The osteomyelitic process extends only relatively slowly within the radio-damaged area of bone. However, it spreads strikingly faster in those cases in which the radio-osteomyelitis develops soon after the radio-therapy and not only years later as a creeping process. In addition to this radio-damage, the infection causes thrombosis of the vessels, even in those of the covering soft tissues; they are thereby further endangered by the additionally reduced circulation. There is no real necrosis of the soft tissues developing. Somewhere, from a fistula, an aperture grows in the covering mucosa or the skin, getting larger and larger. Consequently, more and more bone is exposed

(Fig. 4). This can develop to a complete loss of the covering soft tissues without leading necessarily to a spontaneous mandibular fracture *(Fig. 5)*. In cases of radio-osteomyelitis, a spontaneous fracture is only possible if the radio-damage is not so severe that a real inflammatory reaction can by provoked by the bacterial infection, thereby making an osteolysis by bone resorption possible.

In view of the above mentioned facts, one should try to cure or eliminate the process when the first signs of radio-osteomyelitis appear.

Experiments by *Gowgiel* (1960) in 18 Macacus rhesus monkeys have shown that after fractionated conventional irradiation of the mandible up to a total dose of between 4500 and 11000 rads the onset of necrosis and the dosage of irradiation are in direct relationship. This relationship could not be confirmed in our patients *(Nwoku* 1972). Furthermore, according to *Gowgiel* (1960), the severity and extent of necrosis are in direct relationship to the time of onset. Radio-osteonecrosis appeared to result primarily from the effect of irradiation on the osteocytes. Changes in the blood vessels also played a role in the aggravation and prolongation of the irradiation effects. Radiation produced marked thickening of medial and intimal layers of the arterioles of the mandible while the medium- and large-sized arteries were only involved occasionally. In two of the animals which received 7500 rads a sterile necrosis without spontaneous fracture was found under an intact gingiva, but periosteal bone formation occurred and was responsible for complete regeneration of the mandible which sequestrated in one monkey.

If one transfers, with the necessary caution, findings in non-human primates to human beings, one should expect that the periosteum, even in cases with infected osteoradionecrosis, contains some regenerative potential, especially when the osteomyelitic focus is eliminated. However, in our patient material we have never observed periosteal new bone formation.

In 7 out of our 10 cases, we could demonstrate that resection of radio-osteomyelitic parts of the mandible and immediate reconstruction using autologous ribs or iliac crest can be reasonably successful. We were unable to find a comparable series in the literature.

Of great importance is an adequate resection. As shown in *Fig. 1,* the extent of resection in radio-osteomyelitis requires to be far larger than in common osteomyelitis of the mandible. This was because beyond the area of radio-osteomyelitis of the mandible there is always an additional amount of osteosclerosis. However, the resection must be extended into that area of bone which shows sufficient bleeding, this means resecting beyond marked radio-osteosclerosis. This is ascertained by vertical bone cuts through the buccal cortex *(Fig. 6) (Obwegeser* 1962); it is important that the bone marrow itself is clinically bleeding. Intravital staining will be positive as long as even a minimum of blood supply exists. Only a completely dead piece of bone, such as a sequestrum will not stain *(Fig. 7)*. Even some bleeding from the mandibular artery does not indicate that there is adequate blood supply to produce bony union with an attached bone graft.

It is generally accepted that suppurative mandibular radio-osteomyelitis requires resection in order to avoid subsequent progressive necrosis of the surrounding tissues *(Hauser* 1958, *Masters* et al. 1959, *Obwegesere* 1962, *Grimm* 1971). The longer the suppurative process lasts the worse the local condition becomes. In order to render the patient free of pain, many authors perform resection *(Masters* et al. 1959, *Gorski* and *Kwart* 1962, *Rehrmann* 1962, *Mac Dougall* et al. 1963, *Dargent* et al. 1964, *Marchetta* et al. 1967, *Mounier-Kuhn* et al. 1969, *Grimm* 1971) of the affected part of the mandible. The reconstruction, if any, is generally performed months or years later *(Schroeder* 1958, *Billet* 1971). Even in secondary reconstruction a breakdown of the skin incision was experienced *(Grimm* 1971, *Marciani* and *Trodahl* 1976).

Conclusion

Using resection and immediate reconstruction in cases of ordinary osteomyelitis of the mandible via the oral route, gave very satisfactory results *(Obwegeser* 1960, *Obwegeser* and *Sailer* 1978). We have therefore tried the same procedure in cases of mandibular radio-osteomyelitis and achieved good results *(Obwegeser* 1966).

Depending on the local and general condition of the patient suffering from radio-osteomyelitis,

we have performed either decortication or resection of the affected part of the mandible; in some cases a replacement of the resected part was carried out at a later date, in others a reconstruction was never tried. In both of these groups a temporary fixation or splinting of the remaining part of the mandible was performed in order to maintain correct occlusion. The results obtained by decortication, resection and reconstruction after an infection-free interval will be reported in a subsequent paper.

In 10 cases, we have, in one operation, resected and reconstructed the mandible via the oral route. The experience gained with this method shows clearly that in the resection and immediate reconstruction of the mandible in cases of radio-osteomyelitis the complication rate is much higher than in cases of ordinary osteomyelitis.

Out of 10 cases of radio-osteomyelitis, the grafts had to be removed in 3 cases. In only 2 cases did the graft take without any complication. It is true that in the other 5 cases the grafts took, but suture dehiscence and partial necrosis of the mucosa covering the bone graft occurred. In one of these 5 cases the graft took, but suture dehiscence and partial necrosis of the mucosa covering the bone graft occurred. In one of these 5 cases resuturing was successful. In two cases of dehiscence and in two of partial necrosis of the oral mucosa, the exposed graft was covered by vaselinized iodoform gauze. In spite of this complication the grafts took but postoperative care lasting several months was necessary for healing: After removal of superficial sequestrae granulation tissue was found coming out of the graft and led to spontaneous secondary epithelization.

It seems that it is not absolutely necessary that a bone graft to the oral cavity be completely covered by soft tissues as long as the exposed bone is covered by an adequate dressing. We have made the same observation in the reconstruction of large maxillary defects (*Obwegeser* 1973). We have to make a virtue of necessity, from time to time in using this method.

An important part of the success depends on the quality of the soft tissues. In our experience, damage of the soft tissues, which develops soon after irradiation, is more unfavourable for bone reconstruction than tissues severely affected following irradiation therapy long before.

In cases of immediate reconstruction of the defect, with hindsight, we now recommend more frequently excision of the damaged soft tissues and replacement by healthy ones. But the experienced surgeon will be able to decide in each individual case, during the operation, whether the quality of the soft tissues is suitable for an immediate reconstruction or not. He will also be able to handle eventual complications. After all, it seems to us to be noteworthy that out of 10 cases of radio-osteomyelitis, the graft took in seven.

The infection of bone and soft tissues in radio-osteomyelitis of the mandible seems to us no more a contraindication to immediate reconstruction by means of ribs or iliac crest than in cases of ordinary mandibular osteomyelitis.

Of course, the quality of soft tissues plays an essential part as far as the postoperative complications are concerned. No doubt, the results of primary resection and reconstruction in mandibular radio-osteomyelitis are not as good as in ordinary osteomyelitis. In ordinary osteomyelitis (*Obwegeser* and *Sailer* 1978), in 15 out of 17 cases, the grafts took after resection and immediate reconstruction. There was a very low postoperative complication rate in these 17 cases, not more than in resection and intraoral reconstruction of non-infected cases of endosseous mandibular tumours (*Obwegeser* 1963, *Sailer* 1974). In the 10 cases reported of resection and immediate reconstruction of mandibular segments because of radio-osteomyelitis, the grafted bone took in only 7 cases. Even in these 7 cases, we had considerable difficulty in managing postoperative complications, such as suture dehiscence or necrosis of the covering mucosa. This increased rate of complications cannot be due the operative technique, as the same operators carried out the mandibular resection and reconstruction both in cases of ordinary osteomyelitis as well as in cases of radio-osteomyelitis. The reason for such a relatively high complication rate must be seen in the damage of the soft tissues by irradiation.

It is obvious that the likelihood of a mandibular resection and immediate reconstruction in a case of radio-osteomyelitis giving postoperative problems or not, depends on the quality of the soft tissues. Therefore, we should do everything to improve the quality of the covering soft tissues preoperatively or during operation. This can be

done by removal of the radiodamaged soft tissues and immediate replacement using local tissues and pedicle flaps.

On the other hand, we have the clear impression that the quality of the soft tissues surrounding the radio-osteomyelitic bone improves spontaneously as soon as the radio-osteomyelitic bone is removed and replaced by healthy osseous material. We have observed spontaneous improvement of the radio-damaged soft tissues also in those cases in which resection of the affected mandibular segment was performed but without immediate reconstruction.

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