Deteriorating effect of occlusal disorders on the periodontium of rats with experimental arteriosclerosis

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The periodontal effects of food consistency and of experimental occlusal stresses were clinically studied with healthy and arteriosclerotic rats. Experimental arteriosclerosis was induced with a hypercholesterolemic diet continued for 6 – 12 months. By using food that was finely powdered and moistened, mechanical irritation of the periodontium was reduced to a minimum. The special occlusal and gingival irritants lasting six weeks were an occlusal overload with an overhigh amalgam filling, or an occlusal hypofunction caused by extracting the antagonist tooth.

The arteriosclerotic animals with experimental occlusal stress had gingival changes adjacent to the loaded tooth distinctly more often than around the control tooth on the contralateral side of the mandible of the same animal ($P < 0.001$). The changes seen were local redness and inflammation, and an excessive hyperplastic growth of the gingiva. The gingival changes on the stressed side in control animals were generally slight and the difference compared to the contralateral side was not statistically significant. The control animals showed recession of the gingiva more often than hyperplastic growth of same. In both groups of animals food impaction and deposit of calculus had increased around the teeth that were in occlusal hypofunction. The inflammatory changes were more frequent in the arteriosclerotic animals than in the controls. The cause of the deterioration in the ability to repair tissue damage in arteriosclerotic animals is discussed.

Key-words: Hypercholesterolemic diet; occlusal stress; gingiva

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Occlusal stress and trauma are among the causes giving rise to periodontal changes. Areas subjected to mechanical overload may show inflammation, with typical infiltration of inflammatory cells into the gingiva. Vascularization can increase in the gingival capillaries and the tooth itself can show a tendency to mobility (3, 5, 6, 10, 14, 23). This is accompanied by changes in the activity of some hydrolytic enzymes, as was demonstrated by Virtanen (25). The tissues adjacent to the tooth in question have, however, a general tendency to recover. The migration of the overstressed tooth, followed by resorption and apposition of the alveolar bone adjusts the site of the tooth, and local occlusal stress will thus be eliminated (7, 8, 22, 24).

Laboratory animals have been found to develop a minor local trauma of the periodontium arising from coarse food

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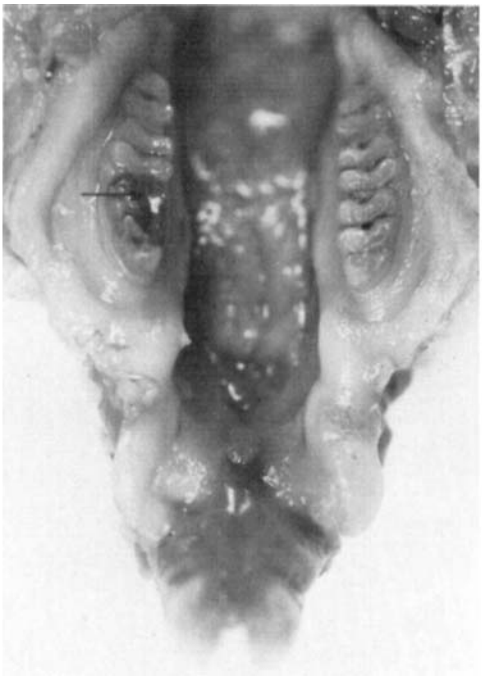

Fig. 1. Mandible of a rat with too high a filling (1 – 2 mm) in the first right molar (arrow). Control animal, after an experimental period of 6 weeks.

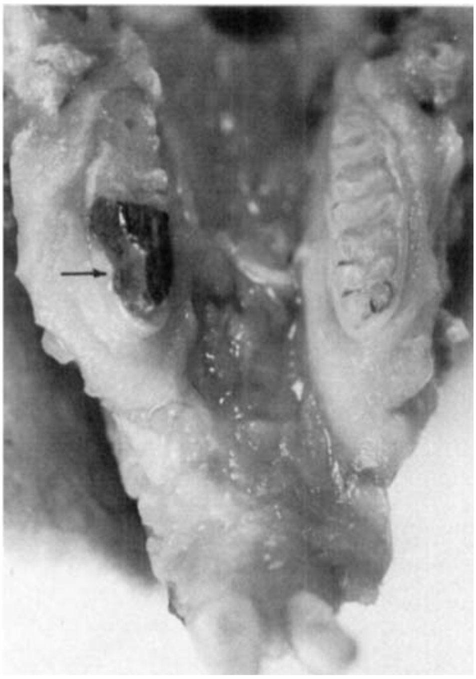

Fig. 2. The filling initiating gingival hyperplasia around the first mandibular molar (arrow). Atherogenic diet animal, after an experimental period of 6 weeks.

Table 1. *Effect of occlusal stress. Experimental group No. 24. Gingival changes (buccal, mesial, lingual)*

	Hyperplasia		Recession	
	Stressed side	Contralateral side	Stressed side	Contralateral side
No changes	8	26	50	59
Slight changes	42	44	21	13
	$P < 0.001$		$P = ns$	
Severe changes	22	2	1	0
	72	72	72	72
	$\chi^2 = 18.050$		$\chi^2 = 0.000$	

Table 2. *Effect of occlusal stress. Control group No. 14. Gingival changes (buccal, mesial, lingual)*

	Hyperplasia		Recession	
	Stressed side	Contralateral side	Stressed side	Contralateral side
No changes	26	32	25	30
	$P = ns$		$P = ns$	
Slight changes	16	10	13	12
Severe changes	0	0	4	0
	42	42	42	42
	$\chi^2 = 1.392$		$\chi^2 = 0.842$	

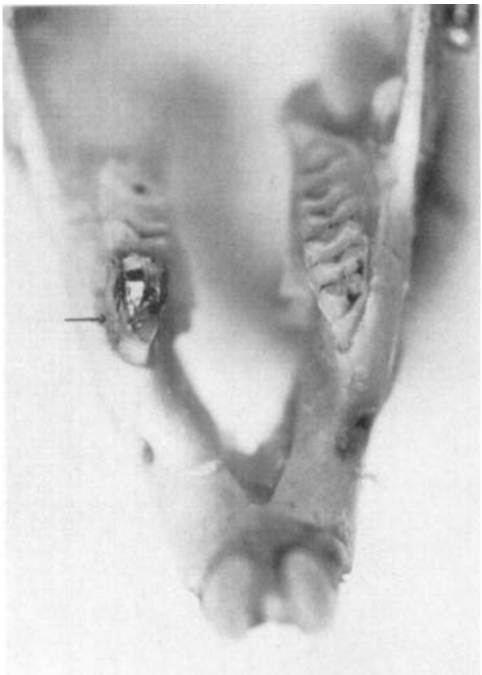

Fig. 3. Marked resorption of the alveolar bone around a molar (arrow) with an over-high filling initiating occlusal and gingival irritation. Atherogenic diet animal after an experimental period of 6 weeks.

(20). Some marginal gingivitis, with inflammatory cells in the gingiva is, however, normal (1). Certain periodontal changes around teeth without an antagonist have been found in test animals (11, 12, 18). These changes include the aggravation of inflammatory cell infiltrations, denser vascularization in the gingival capillaries, and migration and elongation of the remaining tooth, due to its lack of use without an antagonist.

Periodontal response to the occlusal stress and strain, and to other unphysiological irritations arising from the occlusal function in animals with some systemic, endocrine or nutritional disorder, has received less attention. Stahl et al. (18), however, studied the effects of vertical occlusal trauma on the periodontium of protein deprived adult rats. They found that the primary effects were similar to those seen in healthy animals, but that systemic disease interfeded markedly with repair processes. Animals with disorders of carbohydrate metabolism (2) and of calcium metabolism (16, 19) have been studied. Abnormalities in fat metabolism, such as hypercholesterolemia have also been discussed (3, 15, 26). Periodontal disorders in bone formation and increased infiltration of inflammatory cells in response to local irritation have been recorded.

In an investigation carried out on arteriosclerotic rats, distinct differences in the activity of certain enzymic reactions in periodontium have been shown (13). These groups of experimental animals also displayed some clinical features, which the present authors found worth reporting.

MATERIAL AND METHODS

This report is concerned with clinical periodontal reactions to some occlusal disorders in animals on an arteriosclerotic diet. The diet used was the hypercholesterolemic diet according to Thomas & Hartroft (21) as modified by Gresham & Howard (9).

This diet, which was given for 6–8 months, kept the average serum cholesterol in the experimental animals at a level 10 times that in the controls. During this period, distinct degenerative atherosclerotic changes in the aorta developed in all animals, and in about 30 % of them, there were also some changes in the periodontal and gingival arterioles (13).

At first the effect of the mechanical stress of different diets on the periodontium was investigated in 27 animals of the atherogenic diet group and 29 control animals. The latter were given the usual laboratory ratfood prepared either in the normal way (11 rats), or finely powdered and moistened in the same way as the food fed to the experimental group (18 rats).

The special occlusal irritants, induced in the rats for a period of six weeks, were as follows:

1. An occlusal overload with too high an amalgam filling (1–2 mm) in the first molar on the right side of the mandible (Fig. 1). This

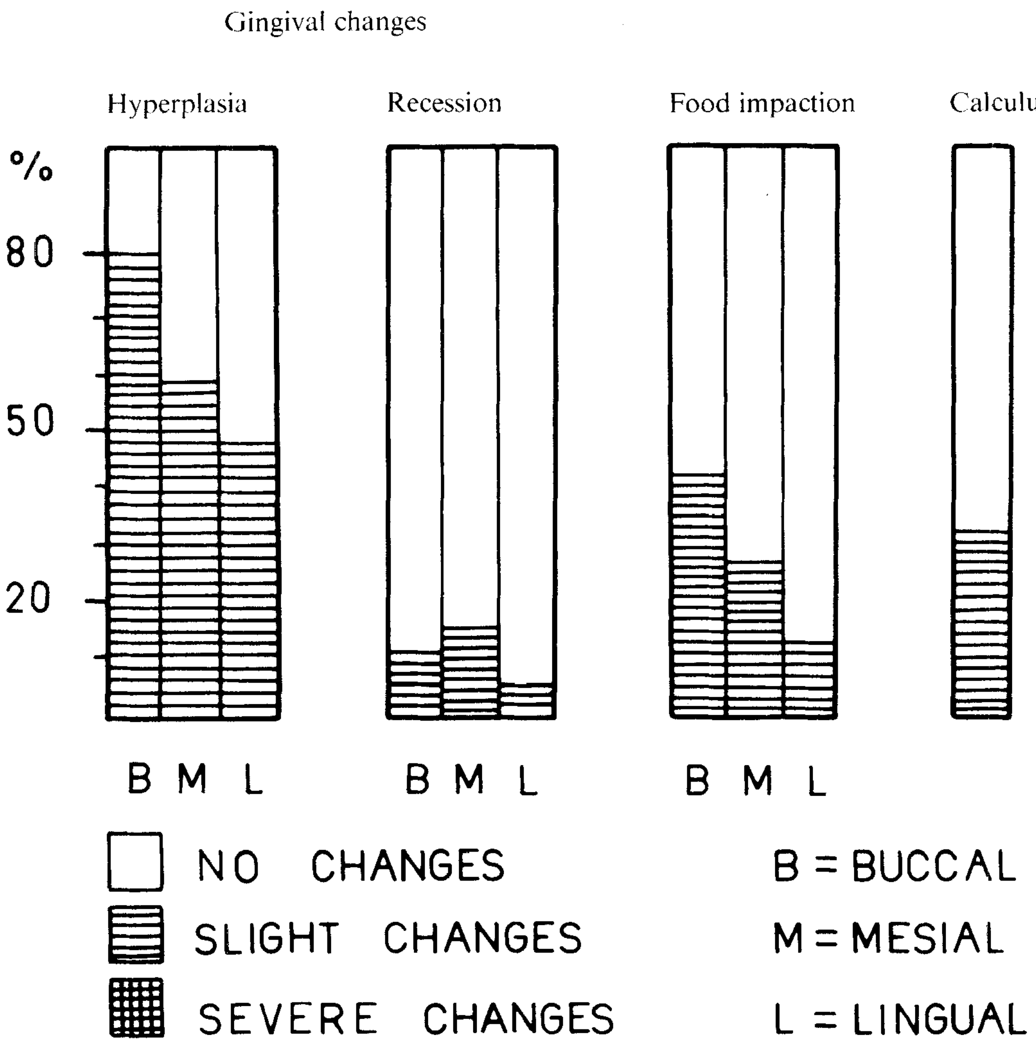

Fig. 4. Effect of diet on the periodontium of rats. (Powdered and moistened food). Experimental group. N = 27.

was applied to 24 experimental and 14 control animals.

2. The filling in the molar was overcontoured, making it anatomically incorrect and thus a source of gingival irritation (Fig. 2). Nine experimental and 10 control animals were given this filling.

3. An occlusal hypofunction was provoked by extracting the antagonist tooth of the first molar on the right side of the mandible. This was performed on 17 experimental and 14 control rats.

The changes of the periodontium around the first molar from stressed and contralateral side of mandible was checked from buccal mesial and lingual side of the tooth. The statistical significance of the changes was tested with the chi-square test (Tables 1, 2).

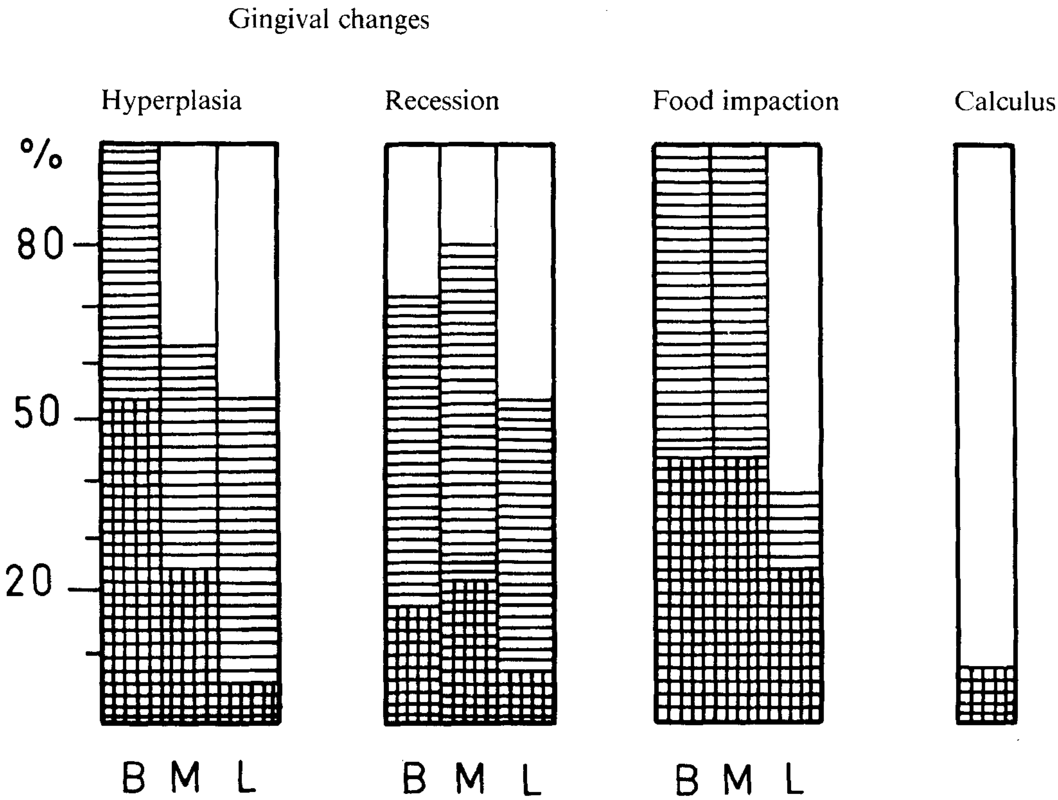

Fig. 5. Effect of diet on the periodontium of rats. (Coarse food). Control group. N = 11. For explanation of symbols see Fig. 4.

RESULTS

The effect of the diet on the periodontium without experimental occlusal disorders

The animals on the atherogenic diet (Fig. 4.) often showed a slight thickening of the gingiva. Typically, the gingival margin extended upwards to the occlusal surface, especially on the buccal side of the tooth, and slight marginal gingivitis was frequent. Control animals fed with powdered and moistened food similar in consistence to that of the experimental group also showed slight gingival changes, but minor pockets of impacted food were more typical than in the atherogenic diet groups. The experimental animals displayed little more calculus than the control animals, but the difference was not marked.

All the control animals eating normal coarse laboratory food (Fig. 5) had very pronounced mechanical trauma in the gingiva, with deep recessions and larger food impaction.

Periodontal effects of experimental occlusal stress

Atherogenic diet groups

In animals with experimental occlusal stress (Fig. 2), gingival changes adjacent to the loaded tooth were distinctly more frequent, and also more severe, than those on the contralateral side of the same animal's mandible (χ^2 = 18.050, P

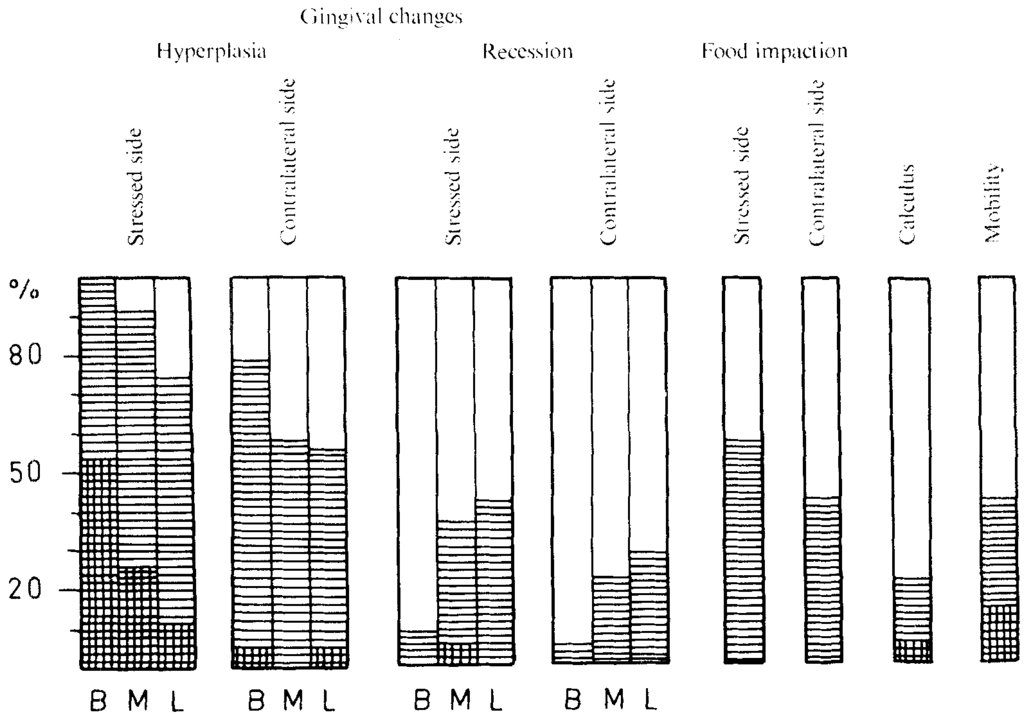

Fig. 6. Effect of occlusal stress. Experimental group. N = 24. For explanation of symbols see Fig. 4.

< 0.001, Table 1). The changes consisted of local inflammation and excessive hyperplastic growth of the gingiva. Gingival recession was less frequent in this group (Fig 6).

The animals with both occlusal stress and an overcontoured filling very often suffered marked gingival changes and resorption of the alveolar bone around these teeth (Figs. 2, 3). Local redness and hyperemia with hyperplasia of the gingival margin were observed. Food impaction had also increased and in some cases a slightly increased mobility of the tooth in question had taken place.

Control groups

The occlusal stress, and especially a combination of occlusal load and gingival stress due to a badly fitted filling, sometimes produced severe local changes and food impaction (Fig. 7). Generally, however, the gingival inflammatory changes of the control animals were less pronounced than those of the atherogenic diet animals. Similarly, the differences between the stressed side and the control side of the same animal were less marked than in the atherogenic diet group (χ^2 = 1.392, P = n.s., Table 2). Typically, the control animals showed recession more often than hyperplastic growth of the gingiva.

The effect of occlusal hypofunction

Changes adjacent to the teeth without antagonists were pronounced in the periodontium of all animals, both in control and atherogenic diet groups, compared with the teeth with antagonists (Figs. 8,

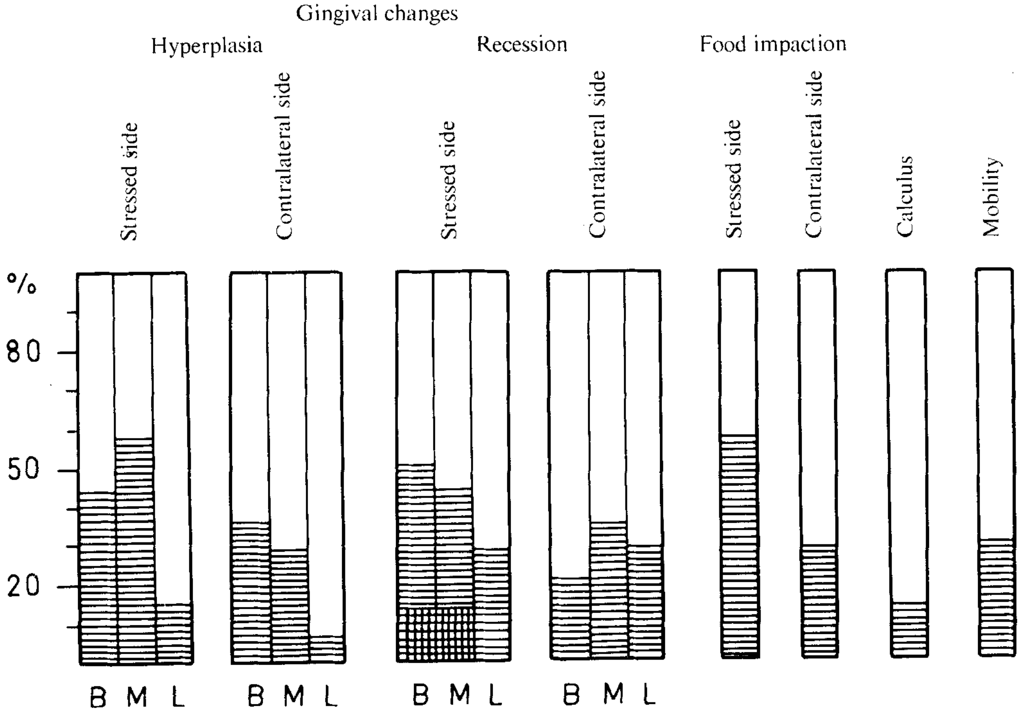

Fig. 7. Effect of occlusal stress. Control group. N = 14. For explanation of symbols see Fig. 4.

9). They consisted of local inflammatory changes, increased food impaction and increased deposit of calculus. In the animals of the control group, however, the changes were less frequent and less severe than in the others. Extraction of the antagonist caused a slightly increased occlusal load on the contralateral side and, obivously due to this, also gingival changes adjacent to the control tooth. Usually the tooth without an antagonist became 0.3–0.5 mm longer during the experimental time of six weeks.

DISCUSSION

The effect of food

The slight differences of the periodontal changes between the experimental and the control rats that had eaten food of the same consistency (powdered and moistened) without experimental occlusal disorders, seem to be due to disorders in the apposition and resorption of the bone of the alveolar crest. These disorders were caused by atherogenic diet and hypercholesterolemia as shown earlier by Doyle et al. (4), Plenk et al. (15) and Wirthlin et al. (26). In this investigation local inflammatory changes caused by experimental food were, however, only mild and of a chronic type in both experimental and control animals. By giving finely powdered food mechanical irritation can be minimized (20). The buccal gingiva was more often subject to a lesion, and the lingual side of a tooth was better protected against food impaction. The bone and the gingiva may then assume an anatomically disadvantageous

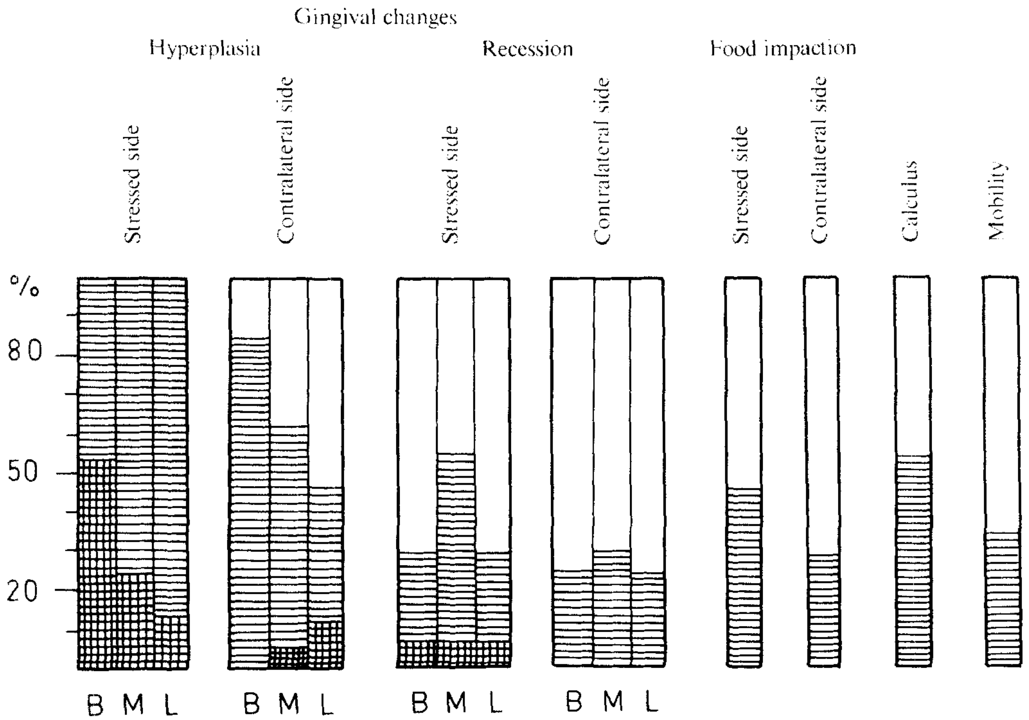

Fig. 8. Effect of occlusal hypofunction. Experimental group. N = 17. For explanation of symbols see Fig. 4.

shape not resistant to the slight mechanical irritation of food, and this cause an inflammatory processes (17).

The effects of occlusal disorders

The periodontal changes on the stressed side of the jaw increased significantly more in the arteriosclerotic than in the control animals, so it seems obvious that these animals' ability to repair tissue damage had deteriorated. This was suggested also by Stahl et al. (18) in their study of some other metabolic disorders. In the present study the animals also lost weight and their general condition became poorer. As shown previously (13), this had connection with the atherogenic diet.

The particular combination occlusal and gingival stress often caused marked inflammatory and hyperplastic changes in the atherogenic diet group, while the changes in the control group were generally gingival recession in the stressed area, and signs of inflammation were not so marked.

Too high a filling often provokes a hyperfunction and simultaneously increased impaction of food and mobility of tooth. This was seen both in test and control animals. Occlusal hypofunction increased gingival changes in both diet groups, and the changes were identical to those found by Stahl et al. (18) and Koivumaa (11). Without occlusal function, all kinds of plaque, and especially calculus, increased around the teeth.

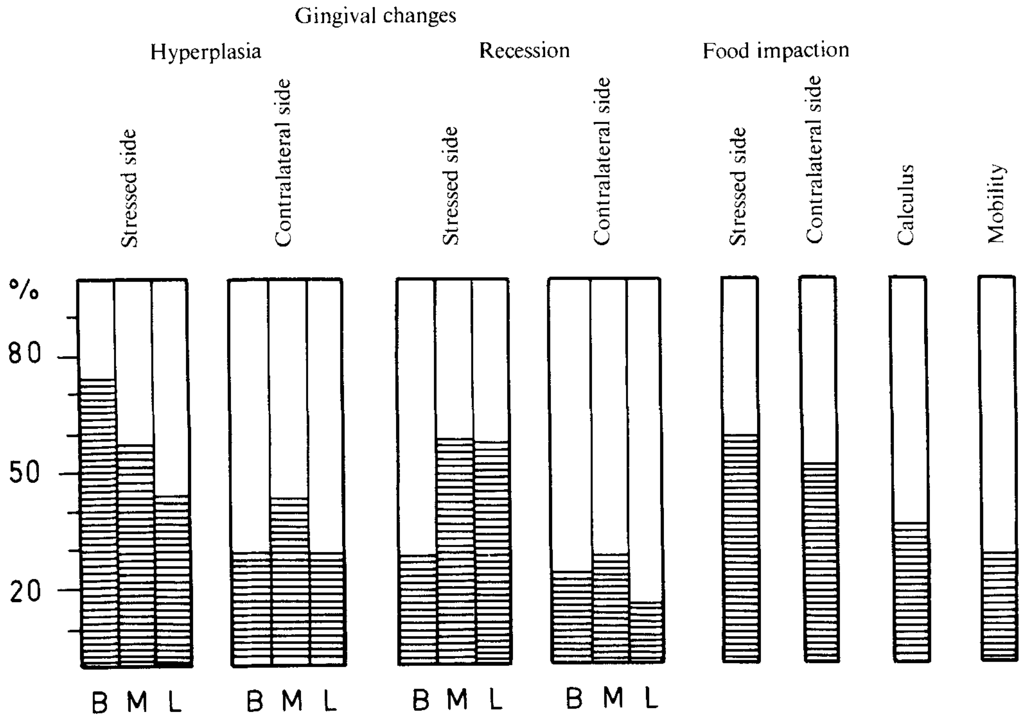

Fig. 9. Effect of occlusal hypofunction. Control group. N = 14. For expalanation of symbols see Fig. 4.

In this investigation the periodontal changes caused by different occlusal disorders were more frequent in the experimental animals in poor condition than in the control animals. A histological and histochemical study of the material, now in progress, may provide more information concerning the relationship of the actual changes of the vessels and other tissues to the occlusal stress and other local irritants.

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