Stomatologija, Baltic Dental and Maxillofacial Journal, 18: 112-21, 2016

The influence of fixed prostheses on periodontal health

Elina Bluma[1], Aldis Vidzis[2], Guntis Zigurs[2]

SUMMARY

The quality of the fixed prostheses is related to the concomitant restoration of the lost oral cavity functions and creation of aesthetics, mechanical strength and hygienic possibilities. While trying to obtain a maximum aesthetic effect and prostheses strength, the hygienic possibilities may be disregarded. The aim of this study was to review the literature regarding the biological (periodontal, peri-implant centred) and aesthetical performance of materials used for fixed constructions in the last decade.

The literature survey was performed in MEDLINE (via PubMed), Wiley Online Library, ProQuest data bases for the period from year 2005 to 2017. Articles (11) reviewing fixed dental prostheses and their impact on the periodontal and peri-implant tissue and aesthetics were included. The review shows that aesthetical outcome of soft tissue health could be improved from PES score 7 up to maximum of 14 scores, but during aesthetical improvement (mucosa around implants and extraction sites, crown gingival connection) health of the soft tissue must be assumed as a priority.

Key words: crown, fixed denture, implant, aesthetics, CAD/CAM.

INTRODUCTION

Disregarding basic principles of prostheses production and at the same time trying to obtain a maximum aesthetic result (1), the inflammation of periodontal tissue may occur. The frequency of biologic complications of fixed constructions mentioned in literature is 0.6% for a single crown, 4% for bridges (2) and the frequency of peri-implant tissue inflammation is in ranges from 80% to 60% (3-5). It is reported in the literature that after 5 years of function, implant supported fixed prostheses demonstrate 8.5% (6), single crowns 7.1% (7) biological complications and 7.1% (7) aesthetical complications. Due to the fact that the study designs, population sizes, as well as the risk and statistic profiles are various and different there are no more specific meta-analysis data. The review article performed by Papaspyridakos *et al.* (8) presented 98.61% survival of implant fixed complete dental prostheses without comments on failure reasons. Requirements for stomatologic services have increased, they have to ensure aesthetic and functional unity, hygienic possibilities and oral health. At the same time, there is a rapid development of material sciences and technologies starting from manual (traditional) framework production up to CAD/CAM (computer-aided design and computer aided manufacturing), from tooth abutment up to implant abutment, digital impression taking (9) and production of monolithic zirconia fixed dental prostheses with acceptable short term results (10). The priorities of implantology have changed, e.g., osseointegration provided by multifactorial aspects is very important for implant stability (11, 12), but the significance of the construction integration in soft tissue remains the same, which, if carefully planned, ensures functions of the denture. The significant etiologic aspect of periodontal and peri-implant tissue inflammation is the presence of bacteria (13-16) influenced by the immune response of the body. Genetic predisposition is also important (17, 18) while Pesce *et al.* could not support the cause – effect theory between bacterial accumulation and periimplantitis (12). The risk of morbidity can be increased by the prosthesis causing direct mechanical tissue injury (during preparation of abutments, impression taking) and /or increasing attachment of the plaque (poor hygiene (19, 20)) and preventing self-cleaning possibilities of the dentures in the oral cavity (20). Inflammation starts as mucositis/gingivitis and with inadequate maintenance transforms in periodontitis/periimplantitis (20, 22-24). For risk reduction, the knowledge, technical skills, treatment planning and mutual communication

[1]*Doctoral studies "Medicine", Riga Stradins University, Riga, Latvia*
[2]*Department of Prosthodontics, Riga Stradins University, Riga, Latvia*

Address correspondence to Elina Bluma, Riga Stradins University, Institute of Stomatology, Department of Prosthetic Dentistry, Dzirciema street 20, LV-1007, Riga, Latvia.
E-mail address: ebra@inbox.lv

of the physician and the dental laboratory technician (constructor of mechanical strength of the prostheses and hygienic aspects) are important. Attention of the professionals involved in the process must be drawn to the timely detection of existing problems to reduce and prevent them (25-27).

To ensure the function of the prostheses (phonetic aspect, chewing), aesthetics, hygiene and mechanic stability at the same time, the following factors should be observed: anatomic shape of the prepared crown, precision of the crown margin (28) and placement against the gingival margin (29-32), shape of the bridge pontic and connection with abutment, site and type of the implant connection with abutment (in relation to the bone or peri-implant tissue – bone level, tissue level), type of abutment production (standard, individual), type of crown fixation on the implant (cemented, screwed) (33), technology solution (the crown on the implant is as one-piece, the crown and abutment are separate (two pieces)), as well as the applied material (metal, zirconium, ceramics, acrylate) (1, 34-38). There are clinical observations that using teeth or implant supported fixed restorations aimed on aesthetics, soft tissues around prostheses could be damaged causing irritation (1).

The purpose of this article was to review the literature regarding the biological (periodontal, peri-implant centred) and aesthetical performance of materials used for fixed constructions in the last decade.

MATERIALS AND METHODS

An electronic literature survey was performed in MEDLINE (via PubMed), Wiley Online Library, ProQuest data bases for the period from year 2005 to 2017. The articles (n=11) reviewing fixed dental prostheses and their impact on the periodontal and peri-implant tissue and aesthetical evaluation were included. The following search terms were selected (MeSH terms): *crown, bridge, CAD/CAM, ceramic, plaque, abutment, aesthetics, hygiene,* applied in different combinations with Boolean operators (AND) and (OR). Obtained publications were imported into reference management software (EndNote, Thomas Reuter, USA). The preference was given to the articles (randomized controlled trials, cohort studies), reporting on aesthetical and clinical evaluation of fixed constructions and published in English. The abstracts of the chosen articles were initially reviewed for possible inclusion in the study, followed by assessment of the full text. The articles which did not focus on the corresponding assignment were excluded. Exclusion criteria were as follows: *in vitro* studies, animal studies, case reports, technical reports, periodontally compromised patients, reviews and studies that evaluated only aesthetics or biological and technical complications. The articles were grouped into studies reporting on results on tooth and implant supported fixed constructions (crowns and bridges).

RESULTS

The electronic search identified a total of 2289 articles. After duplicate references were removed, 1578 studies remained. Applying the inclusion and exclusion criteria to the titles/abstracts, 147 studies were omitted. The full-text was retrieved and

Table 1. Fixed partial dentures: biological and aesthetical evaluation

Author, Year	Nr. of Patients	Time	Frame work	Veneer	Interim	Cement	Clinical assesment						Aesthetic
							PPD mm	PI	GI	BOP	PAL	USPHS	
Zenthofer, 2015, RCT	21	3 yr	CAD / CAM (Zr)	C	NR	Resin	0.7	1	1	NR	0.7	UE	100% satisf.
			Au alloy	C			0.5	0	1		0.5		78% satisf.
Naenni, 2015, RCT	36	3 yr	CAD / CAM (Zr)	pressed ceramic	CS	Resin	UE	UE	NR	UE	NR	UE	75% satisf.
				layered ceramic									100% satisf.
Schmitter, 2009, CCT	30	2 yr	CAD / CAM (Zr)	layered ceramic	Nr	G-I	3.50	NR	NR	NR	NR	NR	NRS pat. 96.6%≥8
													NRS dent. 74%≥8

GI – gingival index; PAL – probing attachment level; C – ceramic; NR – not recorded; UE – used for evaluation; CS – composite; G-I – glass ionomer.

checked. Further (n=136) papers had to be excluded, leading to (n=11) papers which conformed with the inclusion criteria.

Three studies (Table 1) assessed tooth supported fixed dental prostheses (39-41) focused on technical, biological complications and subjective aesthetic questionnaire (numeric rating scale – NRS) of patients (39, 40) and patients/dentists (41). The quality of fixed denture was assessed using modified United States Public Health (USPHS) criteria. Clinical evaluation included testing of probing pocket depth (PPD), probing attachment level (PAL), plaque index (PI), gingival index (GI), bleeding on probing (BOP), radiological examination in recall appointments (2 weeks post cementation, after 6 month, yearly). In the research accomplished by Naenni et al, statistically significant differences of biological outcomes were found between artificial crown with pressed and layered veneering ceramics and intact tooth for control regarding plaque index (p=0.003), differences were higher at fixed partial dentures (40). Patient satisfaction in the pressed group was lower (75%), surface roughness was observed in 18 patients (p=0.056). Zenthofer *et al.* observed marginal integrity of one restoration in beta rating using USPHS criteria (39). Biological values (PI, GI, PPD and PAL) were slightly higher after 3 years than at baseline (p>0.05), but significant higher changes in PPD value were of distal abutment (p<0.011), where aesthetic outcome was *satisfied* to *fully satisfied.* In Schmitter *et al.* study were found no biological complications, but the difference in rated appearance on an NRS between patients (96.4%≥8) and dentists (74%≥8) (41).

To find out preliminary outcomes of using a fixed full arch prosthesis supported by implants, Weinstein *et al.* conducted a clinical prospective study (42). Each patient (n=20) received four implants, acrylic temporary prosthesis, and after 4-6 months of loading final prosthesis, fabricated by means of CAD/CAM. Every 6 months for the first 2 years and yearly, thereafter up to 5 years during follow up visits, radiographs (marginal bone level 0.6±0.3/0.7±0.4), plaque index (PI 8.1±6.0% in 12 month), bleeding index (BOP 2.0±2.2% in 12 month) and patients' satisfaction for function (77.8% and 88.9% – excellent or very good) and aesthetics (66.7% excellent or very good) were assessed by questionnaire (subjective way).

Evaluating single crowns on implants, seven heterogeneuos studies (done for various purposes) were

Table 2. Singe crown on implant: biological and aesthetical evaluation

Author, Year	Nr. of Pat.	Time	Surgery	OII	Crown	Abutment	Clinical assesment				Aesthetical assessment	
							PPD mm	PI	SBI / BOP	BL mm	VAS	PES/WES
Schepke, 2016, RCT	50	1yr	1 st.	Ti	C	Stock	2.32	1	0	↑0.06	90%	10.9/0
						CAD / CAM	2.44	1	0	↑0.11		10.6/0
Fenner, 2015, CCT	28	7.2 yr	NR	Ti	C	Zr	3.87	15%	45%	↑	9.7	USPHS, JI
					M-C	Metal	4.16	28%	56%			
Huynh-Ba, 2015, RCT	32	3 mo	2 st. T1	BL/Ti	NR	NR	3.6	0.24	0.18	↑↑	9.6	13.67
			2 st. T2				3.13	0.27	0.07	↑	9.3	12.51
Migliorati, 2015, RCT	47	2 yr	T1	BL/Ti	NR	NR	3.2	0.1	0.2	↑0.1	NR	15.13
							3.4	0.1				
Payer, 2014, RCT	22	2 yr	2 st.	Zr	C	C	NR	19.38%	9.1%	↓1.48	NR	11.22/0
				Ti				16.05%	7.4%	↓1.43		10.75/0
Santing, 2012, CCT	60	18 mo	2 st.	BL/Ti	C	CAD/ CAM (Zr)	2.75	15%	38.3%	↓0.14	8.9	6.9/7.2 / ICAI/JI
Zembic, 2009, RCT	18	3 yr	2 st.	Ti	C	CAD/ CAM (Zr)	3.2	0.1	0.4	↓1.7	NR	SPM /JI
					M-C	CAD/ CAM (Ti)	3.3	0.1	0.2	↓2.1		SPM/JI

OII – ipmplants; SBI – sulcus bleeding index; BL – bone level; JI – jemt index; M-C – metal ceramic; SPM – spectrophotometer.

included (Table 2) if their research protocol comprised biological and aesthetical parts. Randomized controlled clinical trial (RCT) (n=5), controlled cohort trial (CCT) (n=2) were carried out. Biological complications including radiographic analysis and various indices of soft tissue complications: PPD, GI, BOP, modified plaque index (mPI), modified sulcus bleeding index (mSBI), bone level (BL), keratinized mucosa, gingival biotype were reported. Aesthetical outcomes were evaluated by questionnaire (VAS) and using pink aesthetic score (PES) and white aesthetic scores (WES) or spectrophotometer.

Schepke *et al.*, studying potential benefits of stock versus CAD/CAM abutments, observed soft tissue appearance improvement after 12 months ($p<0.001$) because of papilla fill in proximal areas, soft tissue contour and texture ($p<0.01$) (43). Significantly greater horizontal and vertical defect dimensions on vestibular aspects of implant were observed in Huynh-Ba *et al.* study in the immediately placed implant group ($p<0.05$) within 3 month (44). Evaluating aesthetics and clinical outcomes, Migliorati *et al.* found statistically significant differences between groups with (66.6%) and without (17.3%) soft tissue augmentation ($p<0.001$) when revealed for PES score (45). Lower PES score was observed for thin biotype subgroup ($p=0.03$). The group with augmentation showed increase of keratinised mucosal thickness 34.29% (0.5mm) ($p<0.05$) and recession 10.01% from initial highness (0.02mm). Thick biotype showed minor soft tissue shrinkage and recession with respect to thin biotype ($p<0.05$). Payer *et al.* found differences in PES score outcomes between zirconia and titanium implants (zirconia implants with PES score 11.22 (±1.56) and titanium implants respectively 10.75(±0.7) ($p<0.004$)) (46). The radiographic evaluation revealed significant bone loss ($p<0.001$) within 24 months in both implant groups (zirconia 0.67mm to 1.48mm, titanium 0.16mm to 1.43mm). Evaluation by Santing et al, approved gingival recession which occurred during first 7 months after implant placement, but the volume of mesial papilla increased from 7 to 18 month ($p=0.009$) (47). BOP scores were more frequently at implants than adjacent teeth ($p=0.0032$). The Implant Crown Aesthetic Index (ICAI) showed worse scores ($p=0.004$) in bone augmentation group. The PES also showed a significant difference between augmented (6.9±1.8) and nonaugmented (7.5±1.7) cases ($p<0.02$). The researchers presented aesthetical scores that assess more objective (spectrophotometer, PES, WES, ICAI) and subjective (VAS) in range *clinically acceptable* (43-49). There is observed a tendency for zirconia abutments to improve soft tissue aesthetics (43, 46) Evaluation of inflammation signs around soft tissues showed no biological complications. Higher values of mean PPD, PI, BOP were found at implants compared with neighboring teeth (47, 48) but still within low level (43-46, 49). Measurements were taken at different time points, the last were performed after: 3 months (44), 1 year (43), 18 months (47), 2 years (45, 46), 3 years (48) and 7.5 years (49).

Crowns

The primary etiologic factor of gingival inflammation is a plaque, and by inadequate crown shape its accumulation can be facilitated (29, 35). A single crown can cause inflammation of the periodontal tissue, if the hygienic principles have not been observed during its production (29). If the finish line of the artificial crown disrupts the biologic width and is placed in the connective tissue attachment area, the inflammation may occur. Even with increased hygiene, the gingival inflammation can occur, if the crown preparation margin is located deeply subgingivally (30-32, 50, 51). To replicate prepared tooth or abutment with good accuracy, digital impressions are of similar quality as conventional impressions, however large full-arch fixed partial dentures (FPDs) are exceptions (9). In order to produce a functional crown in the dental technical laboratory, the mechanic, aesthetic and biologic principles must be observed and by physician assessed. Taking care of the periodontal tissue health the precision of the preparation margin, tightness of proximal contacts, conformity of the tooth crown anatomic shape, occlusal morphology and surface smoothness must be checked (29, 39, 40). The contact of the crown and the tooth must be tight and uniform (3, 27, 50, 51). In the clinical trials, to evaluate the quality of artificial crown the USPHS criteria are performed (29, 40, 49). According to the modified USPHS criteria, four scores are given (Alpha, Bravo, Charlie, Delta) to evaluate also aesthetical result (marginal integrity, contours, colour, discoloration of margins). It could be less subjective than questionnaire VAS or numeric rating scale (NRS), however in the future such colour measurement as spectrophotometric analysis leads to more objective aesthetical evaluation in clinical trials and for communication with dental laboratory. While choosing material for crown production it must be taken into account that the bacterial adhesive capacity of the prosthetic material is affected by the surface roughness (40), asperities, free energy of the surface and composition of materials (it is the lowest for ceramic, but the highest for acrylates) (52). The crown surface chipping and becoming rough might lead to

decreased patients satisfaction and increased plaque indices (40). The marginal fit of ceramic materials has improved, it depends on the production system, veneering and aging. The precision of the artificial crown construction is 0 to 74 μm, the CAD/CAM technology ensures clinically acceptable margin fit (120 μm), variations depend on the used system and material (53). Recommended preparation designs for CAD/CAM crown finish line is chamfer (39, 41). The anatomic shape of the crown protects and stimulates gingiva, ensures self-cleaning of the dental crown thus allowing muscles to clean buccal (B) and lingual (L) surfaces of the tooth during the chewing. If the crown is created without any equator, food particles intensively traumatise the tooth in the region of the clinical neck, consequently the plaque and inflammation may occur (3, 54). After formation of tooth equator, the gums are protected and possibilities of denture self-cleaning with a tongue and saliva are facilitated (55-58). It is recommended to observe the proportions of the natural tooth and placement principles in the dental arch.

Bridges

There have been three studies that report on milled (CAD/CAM) zirconia frameworks for fixed dental prostheses (39, 40, 41). The study (CCT), done by Schmitter *et al.* in two year period, emphasized chipping of veneered ceramics of extended bridges while the inflammation signs and aesthetics were satisfactory (41). The randomized, controlled 3-year clinical trial by Naenni *et al.*, pointed to increased probing pocket depth for 3-unit fixed dental prostheses and the patient's satisfaction 100% (40). No data on the shape of pontic are available. Above mentioned articles are not focused on detailed comparison between aesthetics and the signs of inflammation (it can cause error of interpretation), but show the trend of CAD/CAM technology to result in clinically acceptable solution. By replacement of the teeth arch defects, the fixed bridges create conditions for increased retention of food particles (2, 59). The situation is aggravated by the nature of the fixed bridges – they cannot be removed. The clinical experience (3, 58, 60) shows that the patient can refuse even the most aesthetic fixed dentures due to serious oral health problems (52, 55).

The *pontic* has to restore the integrity of the teeth arch causing significant bridge construction contradictions, it has to be aesthetic (effect of the natural tooth) and ensure proper hygiene in long term. (27, 35, 59). In practice, modifications of the fixed bridge pontics are used (52, 61). Shapes of the bridge pontics are envisaged for different localisations and hygienic possibilities (20, 35). *Saddle type* and *conic* pontics are not recommended any more due to difficult hygiene (27). *Sanitary or hygienic* shape of the pontic does not touch the soft tissue (distance to gingiva is ~ 3 mm), it allows free hygiene and the tongue can remove the food residues. Due to aesthetic and phonetic considerations it is recommended for molars of the lower jaw (27). *Bullet-shaped or modified ridge-lap* pontic is suitable for the region of lateral teeth. In the clinical practice (24, 37), it is used most extensively, because the oral surface is created with a hygienic angle. Due to aesthetic considerations, the surface, which is very small, pointed to the vestibular side of the alveolar process, bent inward and reachable with a dental floss is created for this pontic (52, 61). It touches the small band of the soft tissue, preventing soft tissue inflammation and ensuring hygienic possibilities. In case of knife-edge ridge form, the preparation of the pontic is embarrassed. The *ridge-lap (full r-l, total r-l)* pontic is used in the region of the front teeth, however phonetic problems and impaired hygiene due to a widened niche may be present. In the region of front teeth *ovate* pontics of bridges are recommended (35, 61, 62). They are creating good effect of the natural tooth, do not cause any phonetic problems and are easy cleanable with a dental floss, only a motivation is necessary to perform the hygienic activities regularly. The tissue contour beneath the pontic can be changed by the surgical modification of soft tissue and/or bone, or by gradual increase of the pressure with a temporary construction. *Modified ovate* is a type of the pontic that reduces the black triangles interproximally. It is characterised by a smaller vestibular curvature (63, 64).

There is a high stress concentration at connector area, therefore its design should be wider/higher to distribute the load taking into account the anatomical limitations (length of the tooth clinical crown) and aesthetic requirements (41). It is recommended at the height of 3-4 mm, width of 2 mm, i.e., at the equator region of the new crown. The lower is the material strength (ceramics) and higher masticatory forces (premolar, molar region), the thicker should be the connection site (39, 41). If the connection angle (interproximal curvature) is wider, the load is distributed better (65). It is important to balance this fact with aesthetic requirements and hygienic possibilities (39-41). If the connection site of the artificial crown with a pontic tightly fits gingiva, decubitus occurs. Transition from the pontic to supporting crowns must be made so that it creates a flushable space in gingival direction (66), ensuring hygienic possibilities for this region with a tooth

brush and dental floss, but not the large triangular spaces facilitating sticking of food particles.

Implants

In the present research there have been selected five RCT that report on aesthetic and biological evaluation of single implant crowns (43-46, 48) and two CCT (47, 49) (Table 2). The review article by Jung et al summarized that biological complication rate for singe implant crown was 7.1% after 5 years and aesthetical rate can't be calculated because of large heterogeneity between studies (7). The same problem was raised by Benic *et al.* (67). In case of implant, the oral mucous membrane has a large effect on the aesthetics (36, 44, 45, 47, 67). Successful result of dental implantology depends on the soft and bone tissue amount at the start of the treatment (17, 54). It is recommended to insert the implant in a fixed/keratinised mucous membrane the amount of which is different in different positions depending on the localisation in the dental arch (36, 45, 54). If the implant is inserted in a mobile mucous membrane, accumulation of the plaque in peri-implant tissue is more pronounced causing inflammation and bone loss (36). It is believed that there exists a connection between the thickness of soft tissue and bone stability following implant insertion (45, 68, 69). More preferred is a thick biotype of gingiva characterised by deep periodontal pockets, wide and apically placed contact points (7) and higher PES score (45). Thick biotype showed minor soft tissue shrinkage and recession with respect to thin biotype ($p<0.05$) (45). The significant role plays the bone amount that determines implant position, diameter and length to ensure a natural and healthy look of the planned crown at the place where it is connected to the soft tissue (45, 67). The bone amount can be surgically increased (47, 54). When the bone augmentation was conducted, PES score was 6.3, but in nonaugmented cases 7.5 with satisfactory crown aesthetics 75% by ICAI that may occur due to the scar formation during surgery (47). Performing soft tissue augmentation, PES score was 66.6% but in nonaugmented cases17.3% were good aesthetics highlighted the importance of thickening of soft tissues in order to obtain more aesthetic results (45). Different aesthetical measurements (PES, WES, ICAI, spectrophotometry) allow to evaluate, present, compare and communicate with dental technicians. Doubts about reliability of results occur when it is necessary to compare articles with high level of objectivity (spectrophotometry) and high level of subjectivity (ICAI). The bone thickness vestibulary optimal for support and natural soft tissue shape is important to take into account (45). It can be considered that the smaller the implant diameter, the thicker bone should be left vestibulary thus reducing gingival recession. The larger the implant diameter, the deeper it should be placed in the bone to obtain more natural gingival profile (1, 70). Advantages of the straight or parallel wall of the implant platform include lower pressure on the peri-implant tissue thus reducing recession of soft tissue and significant gingival remodelling following the implant insertion (70). *Platform switch* is a type of platform (multifactorial phenomenon) (54) that connect the implant of a narrow diameter with a wide abutment and moves the bacterial plaque attaching microspace further from the bone ridge. This type of platform allows observe reduced bone ridge resorption. At the same time, the amount of soft tissue becomes thicker and formation of papilla is facilitated (37, 43). In the bone augmentation case the volume of interdental papilla increased during follow up within 11 months without any proved explanation (47). The level of interdental papilla is related to the marginal bone level at adjacent teeth (71), and might be influenced by crown pressure on mucosa, coronally displacing to mesial and distal sites (72). Abutment as a transitional part connects implant and artificial crown. The place where the implant is connected to the abutment is critical for gingival health, because there is a microspace with possible micromovements (37, 68). If the abutment screw becomes looser, bacterial plaque accumulates in the microspace, colonisation of bacteria occurs followed by inflammation of peri-implant tissue and bone resorption (5, 54). Biological compatibility between the foreign body (abutment) and soft tissue forms a barrier for bacterial penetration (73). The importance of soft tissue integration for implant success is the same as that of osseointegration (11, 12). Considering technical and aesthetic factors, different abutment materials can be chosen: titanium (48, 49), gold, zirconium oxide (43, 47, 48) and aluminium oxide ceramics (49). These materials should be able to get integrated in living tissue (73). Payer el al. proved that using zirconi abutments PES (11.22±1.56) is higher ($p<0.004$) than using titanium abutments (10.75±0.7) (45). This is similar to Linkevicius el al. findings in the systematic review: higher PES at Zr abutment/Zr implant site compared to metal abutments and Ti implants (74). In literature, it has been stated that uneven surface attaches bacterial plaque, but reduction of the surface roughness by less than 0.2 μm has no impact on the accumulation of bacterial plaque (75). For particularly polished abutments the probe insertion depth in peri-implant

pockets increases (54). It is considered that in case the thickness of gingiva exceeds 3 mm, the colour of implant, abutment or crown material does not affect the aesthetics, since it is not visible through the gingival (54,73). Zirconium (Zr) abutment is characterised by good integration in soft tissue, it is aesthetic, reduces formation of the plaque and colonisation of bacteria, and facilitates involvement of the mucous membrane epithelium. The abutments made in CAD/CAM technology present good aesthetical and biological results (43, 46-49).

For connection of several implants to form a bridge abutment there is wide range of possible technical solutions. Always, when choosing the implant, transfers, abutments, pontics, bars or other connections, a stable contact with a soft tissue should be made, taking into account biomechanical and aesthetic principles (15, 18, 67).

To find out the preliminary outcomes of using a fixed full arch prosthesis supported by implants, Weinstein el al. conducted clinical prospective study (42). During each visit PI, mSBI, patient's satisfaction for function and aesthetics was evaluated. The results showed reduced plaque from 11.8% to 8.1% and bleeding scores from 3.8% to 2.0% as outcome of good patients oral health instructions. The aesthetics was judged as excellent or very good by 66.7% of patients, phonetics by 77.8% and mastication by 88.9% of patients (most of the patients were complete denture wearers, seeking for fixed construction).

If the fixed construction on the implant is produced, the crown contact sites with a soft tissue vestibulary and in the interdental region should be elaborated. Depending on the atrophy degree of the implant supporting bone and the necessity to ensure aesthetics, for the artificial crown on the implant only the crown part of the tooth or the crown part together with gingival part should be replaced. If the bone atrophy is severe, both the crown part of the tooth should be replaced and imitation of soft tissue should be performed ensuring possibilities for hygienic measures (15).

When creating an implant supported bridge or blocked crowns, a pontic fitting tightly to the soft tissue must be planned, if necessary the soft tissue should be adapted in due time (1). If two contiguous implants of large diameter are blocked, modelling of the framework is technically difficult, particularly in the interdental region, since it must conform to the hygienic requirements and simultaneously provide amount for ceramic layer (7, 20).

If *the implants supported fixed bridge* is prepared in case of complete teeth loss, the hygienic aspects should be elaborated already in the treatment plan (ability of the patient to clean and possibilities to perform preventive measures) (20, 42). Before try-in and delivery, the technician has to check whether the interdental brush goes through and does not cause any pressure on the soft tissue. The prostheses that tightly touches gingiva can make the cleansing more difficult, but can ensure phonation function not allowing free flow of the air between the denture and alveolar surface. For lower jaw construction, in distal regions the shape of the pontic ensuring hygiene is recommended (irrespective of the prostheses size or material).

If the suprastructures of the implant are placed, gingival recession can be observed (possible deterioration of aesthetics). Therefore the temporary construction is recommended, but abutments should be chosen and impression for artificial crown should be taken at least 3 months following implant insertion (1).

If the basis of the bridge is made of acryl, the external surface in the region of the front teeth should be made adequately imitating the gingival surface, but the surface of the denture basis against the peri-implant tissue should be polished smooth, possibly making it of the metallic alloy (Cr-Co, Ti) (20).

The information necessary for creation of the appropriate denture should be transferred to the dental laboratory technician in writing and with photography or in direct conversation for the dental laboratory technician to be able to make a denture ensuring its quality and precision. The most important principle for choice of the denture construction is a simpler denture design covering the most necessary oral tissue (alveolar process, palate, gingiva) minimally, but at the same time ensuring retention, stability, support and hygienic principles. To prevent the risk of soft tissue pathologies the following must be observed:

- patient choice – the overall health (over years changes of the general health occur) (4, 76) and harmful habits should be assessed evaluation of the bone atrophy, determination of occlusion, hygiene (the larger is CPITN (community periodontal *index* of treatment needs) before the prosthetics, the larger is a possibility for biologic complications), gingival biotype and ability of the patient to cooperate to ensure hygiene (12, 15, 26), history of periodontitis is in relation to a periimplantitis (12, 22, 76, 77);
- treatment planning and repeated evaluation of the plan at different stages (correction,

rehabilitation phase). The planning strategy is important (time of implant insertion following extraction, soft tissue and bone augmentation, loading) (23, 44, 45, 47);
- development of the prosthetic construction balancing mechanical strength, aesthetics and possibilities of hygiene to obtain a denture with a long-term performance (3-5, 26);
- prevention of etiological factors – to observe recommendations for gingiva formation (load, duration); consider implant insertion in the bone following extraction (T1-T4) and possibility to insert implant in the keratinised mucous membrane; the bone amount; distance between the implants; gingivectomy; gingival plastics; modifications of the soft tissue (surgically, with temporary crowns) and alveolar bone with atraumatic approach (15, 23);
- care program of periodontal/peri-implant tissue (supportive periodontal therapy) . To avoid missing of the first inflammation signs, the examination should be performed in due time and regularly and the diagnosis should be stated (10, 23, 24, 45). Clinical and x-ray examinations of the implant are recommended at the delivery of the denture and at each further control visit to assess iatrogenic factors (cement residues, imprecise construction, ability to perform interproximal hygiene), to determine presence of the plaque PD 5 mm and more, BOP and/or purulent exudation during slight probing (0.25 N), and the obtained data should be compared to the initial parameters (26,78);
- differentiation from mucostis/gingivitis, occlusal overload, retrograde inflammation and periapical damage (19).

CONCLUSIONS

CAD/CAM implants, abutments, frameworks for crowns and bridges show clinically acceptable biological results in oral cavity with aesthetical results PES scores above 6 (clinical acceptable) and high patients' subjective satisfaction in one to three years period of time. Aesthetical outcome could be improved from PES score 7 to maximum - 14 scores. During aesthetical improvement (mucosa around implants and extraction sites, crown gingival connection) soft tissue health must be assumed as a priority.

The prosthetic materials with lower possibilities of bacterial plaque adherence and better polishing properties (zirconium, ceramics, metal) are advisable.

According to this study there is no evidence that aesthetical construction increases soft tissue inflammation, however the interconnectedness between aesthetics and soft tissue health remains actual topic for future research.

STATEMENT OF CONFLICT OF INTEREST

The authors state no conflict of interest.

REFERENCES

1. Rodriguez AM, Rosenstiel SF. Esthetic considerations related to bone and soft tissue maintenance and development around dental implants: report of the Committee on research in fixed prosthodontics of the American Academy of fixed prosthodontics. *J Prosthet De*nt 2012; 108:259-67.
2. Goodacre CJ, Bernal G, Rungcharassaeng K, Kan JY. Clinical complications in fixed prosthodontics. *J Prosthet Dent* 2003;90:31-41.
3. Zitzmann NU, Berglundh T. Definition and prevalence of peri-implant diseases. *J Clin Periodontol* 2008;35:286-91.
4. Marrone A, Lasserre J, Bercy P, Brecx MC. Prevalence and risk factors for peri-implant disease in Belgian adults. *Clin Oral Implants Re*s 2013;24:934-40.
5. Fransson C, Lekholm U, Jemt T, Berglundh T. Prevalence of subjects with progressive bone loss at implants. *Clin Oral Implants Res* 2005;16:440-6.
6. Pjetursson BE, Thoma D, Jung R, Zwahlen M, Zembic A. A systematics review of the survival and complication rates of implant-supported fixed dental prostheses (FDPs) after a mean observation period of at least 5 years. *Clin Oral Implants Res* 2012;23:22-38.
7. Jung RE, Zembic A, Pjetursson BE, Zwahlen M, Thoma DS. Systematic review of the survival rate and the incidence of biological, technical, and aesthetic complications of single crowns on implants reported in longitudinal studies with a mean follow-up of 5 years. *Clin Oral Implants Res* 2012;23:2-21.
8. Papaspyridakos P, Mokti M, Chen CJ, Benic GI, Gallucci GO, Chronopoulos V. Implant and prosthodontic survival rates with implant fixed complete dental prostheses in the edentulous mandible after at least 5 years: a systematic review. *Clin Implant Dent Relat Res* 2014;16:705-17.
9. Ahlholm P, Sipilä K, Vallittu P, Jakonen M, Kotiranta U. Digital versus conventional impressions in fixed prosthodontics: a review. *J Prosthodont* 2016 Aug 2. [Epub ahead of print].
10. Abdulmajeed AA, Lim KG, Närhi TO, Cooper LF. Complete-arch implant-supported monolithic zirconia fixed dental prostheses: A systematic review. *J Prosthet Dent* 2016;115:672-7.
11. Koka S, Zarb G. On osseointegration: the healing adaptation principle in the context of osseosufficiency, osseoseparation, and dental implant failure. *Int J Prosthodont* 2012;25:48-52.
12. Pesce P, Menini M, Tealdo T, Bevilacqua M, Pera F, Pera P. Peri-implantitis: a systematic review of recently published papers. *Int J Prosthodont* 2014;27:15-25.
13. Lang NP, Berglundh T, Heitz-Mayfield LJ, Pjetursson BE, Salvi GE, Sanz M. Consensus statements and recommended clinical procedures regarding implant survival and complications. *Int J Oral Maxillofac Implants* 2004;19:150-4.
14. Renvert S, Persson GR. Periodontitis as a potential risk factor for peri-implantitis. *J Clin Periodont*ol 2009;36:9-14.

15. Algraffee H, Borumandi F, Cascarini L. Peri-implantitis. *Br J Oral Maxillofac Surg* 2012;50:689-94.
16. Klinge B, Hultin M, Berglundh T. Peri-implantitis. *Dent Clin North Am* 2005;49:661-76.
17. Cekici A, Kantarci A, Hasturk H, Van Dyke TE. Inflammatory and immune pathways in the pathogenesis of periodontal disease. *Periodontol 2000* 2014;64:57-80.
18. Charalampakis G, Leonhardt Å, Rabe P, Dahlén G. Clinical and microbiological characteristics of peri-implantitis cases: a retrospective multicentre study. *Clin Oral Implants Res* 2012;23:1045-54.
19. Nguyen-Hieu T, Borghetti A, Aboudharam G. Peri-implantitis: from diagnosis to therapeutics. *J Investig Clin Dent* 2012;3:79-94.
20. Ikai H, Kanno T, Kimura K, Sasaki K. A retrospective study of fixed dental prostheses without regular maintenance. *J Prosthodont* Res 2010;54:173-8.
21. Stetler KJ. Significance of the width of keratinized gingival on the periodontal status of teeth with submarginal restorations. *J Periodontol* 1987;58:696-700.
22. Pesce P, Canullo L, Grusovin MG, de Bruyn H, Cosyn J, Pera P. Systematic review of some prosthetic risk factors for periimplantitis. *J Prosthet Dent* 2015;114:346-50.
23. Smeets R, Henningsen A, Jung O, Heiland M, Hammächer C, Stein JM. Definition, etiology, prevention and treatment of peri-implantitis – a review. *Head Face M*ed 2014;3:10-34.
24. Salvi GE, Zitzmann NU. The effects of anti-infective preventive measures on the occurrence of biologic implant complications and implant loss: a systematic review. *Int J Oral Maxillofac Implants* 2014;29:292-307.
25. Avrampou M, Kamposiora P, Papavasiliou G, Pissiotis A, Katsoulis J, Doukoudakis A. Design of removable partial dentures: a survey of dental laboratories in Greece. *Int J Pro*sthodont 2012;25:66-9.
26. De Backer H, Van Maele G, De Moor N, Van den Berghe L. Survival of complete crowns and periodontal health: 18-year retrospective study. *Int J Prosthodont* 2007;20:151-8.
27. Edelhoff D, Spiekermann H, Yildirim M. A review of esthetic pontic design options. *Quintessence Int* 2002;33:736-46.
28. Felton DA, Kanoy BE, Bayne SC, Wirthman GP. Effect of in vivo crown margin discrepancies on periodontal health. *J Prosthet Dent* 1991;65:357-64.
29. Kosyfaki P, del Pilar Pinilla Martín M, Strub JR. Relationship between crowns and the periodontium: a literature update. *Quintessence Int* 2010;41:109-26.
30. Knoernschild KL, Campbell SD. Periodontal tissue responses after insertion of artificial crowns and fixed partial dentures. *J Prosthet Dent* 2000;84:492-7.
31. Matthews DC, Tabesh M. Detection of localized tooth-related factors that predispose to periodontal infections. *Periodontology 2000*;34:136-50.
32. Schatzle M, Lang NP, Anerud A, Boysen H, Burgin W, Loe H. The influence of margins of restorations on the periodontal tissues over 26 years. *J Clin Periodontol* 2001;28:57-64.
33. Lemos CA, de Souza Batista VE, Almeida DA, Santiago Júnior JF, Verri FR, Pellizzer EP. Evaluation of cement-retained versus screw -retained implant-supported restorations for marginal bone loss: A systematic review and meta-analysis. *J Prosthet Dent* 2016;115:419-27.
34. Klinge B, Hultin M, Berglundh T. Peri-implantitis. *Dent Clin North Am* 2005;49:661-76.
35. Becker CM, Kaldahl WB. Current theories of crown contour, margin placement, and pontic design. 1981. *J Prosthet Dent* 2005;93:107-15.
36. Chung DM, Shotwell JL, Misch CE, Wang H. Significance of keratinized mucosa in maintenance of dental implants with different surfaces. *J Periodontol* 2006;77:1410-20.
37. Enkling N, Johren P, Klimberg T, Mericske-Stern R. Open or submerged healing of implants with platform switching: a randomized, controlled clinical trial. *J Clin Periodontol* 2011;38:374-84.
38. Zarone F, Russo S, Sorrentino R. From porcelain-fused-to-metal to zirconia: clinical and experimental considerations. *Dent Mater* 2011;27:83-96.
39. Zenthöfer A, Ohlmann B, Rammelsberg P, Bömicke W. Performance of zirconia ceramic cantilever fixed dental prostheses: 3-year results from a prospective, randomized, controlled pilot study. *J Prosthet Dent* 2015;114:34-9.
40. Naenni N, Bindl A, Sax C, Hämmerle C, Sailer I. A randomized controlled clinical trial of 3-unit posterior zirconia-ceramic fixed dental prostheses (FDP) with layered or pressed veneering ceramics: 3-year results. *J Dent* 2015;43:1365-70.
41. Schmitter M, Mussotter K, Rammelsberg P, Gabbert O, Ohlmann B. Clinical performance of long-span zirconia frameworks for fixed dental prostheses: 5-year results. *J Oral Rehabil* 2012;39:552-7.
42. Weinstein R, Agliardi E, Fabbro MD, Romeo D, Francetti L. Immediate rehabilitation of the extremely atrophic mandible with fixed full-prosthesis supported by four implants. *Clin Implant Dent Relat Res* 2012;14:434-41.
43. Schepke U, Meijer HJ, Kerdijk W, Raghoebar GM, Cune M. Stock versus CAD/CAM customized zirconia implant abutments - clinical and patient-based outcomes in a randomized controlled clinical trial. *Clin Implant Dent Relat Res* 2017;19:74-84.
44. Huynh-Ba G, Meister DJ, Hoders AB, Mealey BL, Mills MP, Oates TW, et al. Esthetic, clinical and patient-centered outcomes of immediately placed implants (Type 1) and early placed implants (Type 2): preliminary 3-month results of an ongoing randomized controlled clinical trial. *Clin Oral Implants Res* 2016;27:241-52.
45. Migliorati M, Amorfini L, Signori A, Biavati AS, Benedicenti S. Clinical and Aesthetic Outcome with Post-Extractive Implants with or without soft tissue augmentation: A 2-year randomized clinical trial. *Clin Implant Dent Relat Res* 2015;17:983-95.
46. Payer M, Heschl A, Koller M, Arnetzl G, Lorenzoni M, Jakse N. All-ceramic restoration of zirconia two-piece implants--a randomized controlled clinical trial. *Clin Oral Implants Res* 2015;26:371-76.
47. Santing HJ, Raghoebar GM, Vissink A, den Hartog L, Meijer HJ. Performance of the Straumann Bone Level Implant system for anterior single-tooth replacements in augmented and nonaugmented sites: a prospective cohort study with 60 consecutive patients. *Clin Oral Implants Res* 2013;24:941-8.
48. Zembic A, Bösch A, Jung RE, Hämmerle CH, Sailer I. Five-year results of a randomized controlled clinical trial comparing zirconia and titanium abutments supporting single-implant crowns in canine and posterior regions. *Clin Oral Implants Res* 2013;24:384-90.
49. Fenner N, Hämmerle CH, Sailer I, Jung RE. Long-term clinical, technical, and esthetic outcomes of all-ceramic vs. titanium abutments on implant supporting single-tooth reconstructions after at least 5 years. *Clin Oral Implants Res* 2016;27:716-23.
50. Goldberg PV, Higginbottom FL, Wilson TG, Jr. Periodontal considerations in restorative and implant therapy. *Periodontology 2000* 2001;25:100-9.
51. Gunay H, Seeger A, Tschernitschek H, Geurtsen W. Placement of the preparation line and periodontal health--a prospective 2-year clinical study. *Int J Periodontics Restorative Dent* 2000;20:172-81.
52. Zigurs G, Vidzis A, Brinkmane A. Halitosis manifestation and prevention means for patients with fixed teeth dentures. *Stomatologija* 2005;7:3-6.
53. Abduo J, Lyons K, Swain M. Fit of zirconia fixed partial denture: a systematic review. *J Oral Rehabil* 2010;37:866-76.
54. Happe A, Körner G. Biologic interfaces in esthetic dentistry. Part II: the peri-implant/restorative interface. *Eur J Esthet Dent* 2011;6:226-51.
55. Plotniece-Baranovska A, Soboleva U, Rogovska I, Apse P. Changes in the periodontal condition after replacement of swaged crowns by metal. *Stomatologija* 2006;8:85-7.
56. Rawal SY. Traumatic lesions of the gingival: a case series. *J Periodontol* 2004;75:762-9.
57. Tarnow D, Magner A, Flecher P. The effect of the distance from the contact point to the crest of bone on the presence or absence of the interproximal dental papilla. *J Periodontol* 1992;6:886-95.

58. Yang L, Davarpanah M, Wright W. Restorative and periodontic procedures. *CDA J* 1988;16:25-30.
59. Cosyn JR, Packet M, Cleymaet R, Bruyn H. Disparity in embrasure fill and papilla height between tooth- and implant-borne fixed restorations in the anterior maxilla: a cross-sectional study. *J Clin Periodontol* 2013;40:728-33.
60. Newcomb JM. The relationship between the location of subgingival crown margins and gingival inflammation. *J. Periodontol* 1974;45:151-4.
61. Del Castillo R, Ercoli C, Delgado JC, Alcaraz J. An alternative multiple pontic design for a fixed implant-supported prosthesis. *J Prosthet Dent* 2011;106:198-203.
62. Raigrodski AJ, Schwedhelm ER, Chen YW A simplified technique for recording an implant-supported ovate pontic site in the esthetic zone. *J Prosthet Dent* 2014;111:154-8.
63. Liu CL. Use of a modified ovate pontic in areas of ridge defects: a report of two cases. *J Esthet Restor Dent* 2004;16:273-81.
64. Zetu L, Wang HL. Management of inter-dental/inter-implant papilla. *J Clin Periodontol* 2005;32:831-9.
65. Oh W, Götzen N, Anusavice KJ. Influence of connector design on fracture probability of ceramic fixed-partial dentures. *J Dent Res* 2002;81:623-7.
66. Wood M. Resin- bonded fixed partial dentures II. Clinical findings related to prosthodontic characteristics after approximately 10 years. *J Prosthet Dent* 1996;76:368-73.
67. Benic GI, Wolleb K, Sancho-Puchades M, Hämmerle CH. Systematic review of parameters and methods for the professional assessment of aesthetics in dental implant research. *J Clin Periodontol* 2012;39:160-92.
68. Jia-Hui F, Lee A, Hom-Lay W. Influence of tissue biotype on implant esthetics. *Int J Oral Maxillofac Implants* 2011;26:499-508.
69. Linkevicius T, Apse P, Grybauskas S, Puisys A. The influence of soft tissue thickness on crestal bone changes around implants: A 1-year prospective controlled clinical trial. *Int J Oral Maxillofac Implants* 2009;24:712-9.
70. Chen ST, Buser D. Clinical and esthetic outcomes of implants placed in postextraction sites. *Int J Oral Maxillofac Implants* 2009;24:186-217.
71. Kourkouta S, Dedi KD, Paquette DW, Mol A. Interproximal tissue dimensions in relation to adjacent implants in the anterior maxilla: clinical observations and patient aesthetic evaluation. *Clin Oral Implants Re*s 2009;20:1375-85.
72. Buser D, Wittneben J, Bornstein MM, Grütter L, Chappuis V, Belser UC. Stability of contour augmentation and esthetic outcomes of implant-supported single crowns in the esthetic zone: 3-year results of a prospective study with early implant placement postextraction. *J Periodontol* 2011;82:342-9.
73. Welander M, Abrahamsson I, Berglundh T. The mucosal barrier at implant abutments of different materials. *Clin Oral Implants Res* 2008;19:635-41.
74. Linkevicius T, Vaitelis J. The effect of zirconia or titanium as abutment material on soft peri-implant tissues: a systematic review and meta-analysis. *Clin Oral Implants Res* 2015;26:139-47.
75. Bollen CM, Lambrechts P, Quirynen M. Comparison of surface roughness of oral hard materials to the threshold surface roughness for bacterial plaque retention: a review of the literature. *Dent Mater* 1997;13:258-69.
76. Renvert S, Polyzois I. Risk indicators for peri-implant mucositis: a systematic literature review. *J Clin Periodontol* 2015;42:172-86.
77. Heitz-Mayfield LJ. Peri-implant diseases: diagnosis and risk indicators. *J Clin Periodontol* 2008;35:292-304.
78. Preshaw PM, Heasman PA. Periodontal maintenance in a specialist periodontal clinic and in general dental practice. *J Clin Periodontol* 2005; 32:280-6.

Received: 16 02 2016
Accepted for publishing: 28 12 2016