Int J Clin Exp Med 2016;9(7):14077-14086
www.ijcem.com /ISSN:1940-5901/IJCEM0028173

Original Article

Post-extraction socket changes in diabetic patients - a retrospective study

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Received March 14, 2016; Accepted June 8, 2016; Epub July 15, 2016; Published July 30, 2016

Abstract: It is very difficult to determine the time point of inserting implants for diabetic patients. And less we know about how diabetic sockets change with time. Based on the previous studies on non-diabetic socket healing, we analysed pre- and post-extraction cone beam computed tomography images of type 2 diabetes patients (n=93) and, age and sex matched non-diabetic controls (n=93) to investigate post-extraction socket dimensional changes. Post-extraction follow-up time ranged from three to 24 months. Socket dimensions (socket width and height, alveolar ridge width and height) were compared between the groups using computed tomography images. No significant differences between the groups were observed in pre-extraction socket dimensions. Post-extraction socket width and depth were significantly higher in diabetic group compared to non-diabetic group in all follow-up time points (3, 4-6, 7-12 and 13-24 months). Differences in alveolar ridge width and height between the groups at all the post-extraction time points were not statistically significant. An unfavourable, delayed early post-extraction socket healing was observed in diabetic patients. Therefore, implant insertion could be delayed four to six months post-extraction in diabetic patients for improved prognosis of prosthetic management.

Keywords: Socket dimensions, post-extraction socket, dental implants, diabetes

Introduction

Loss of dentition results in morphological changes in both hard and soft tissues in the alveolar region. Extraction of teeth is followed by horizontal and vertical changes in the dimension of the alveolar socket/bone [1, 2]. These changes occur more rapidly in the first 3-6 months of the post-extraction period [3, 4]. Maintenance and preservation of alveolar bone after extraction is necessary to ensure both functional stability and aesthetics of the prosthesis/restoration. The time and magnitude of these post-extraction socket changes are critical for planning implant-based treatment strategies to manage edentulous space [5]. The long-term success of an implant is dependent on effective osseointegration, which is influenced by the amount of healthy bone at the implant placement site. Hence, the ridge dimensions of the edentulous space are critical for implant placement [6]. If the socket has severe bone defects, it cannot provide adequate bone to ensure primary stability and osseointegration of the implant-based prosthesis [7]. Local factors that influence residual ridge resorption include location, trauma/surgical technique during extraction, the number of teeth extracted, bone density, infection, and habits such as smoking. Bone healing and resorption can also be affected by systemic factors, such as age, gender, metabolic disorders, and hormonal dysregulation, including that associated with diabetes mellitus.

In 2013, 382 million people were diagnosed with diabetes. This number is expected to grow to 592 million by 2035 [8-11]. Type 2 diabetes is the most common form of diabetes mellitus and accounts for about 90% of clinical cases [12]. Type 2 diabetes is characterized by hyperglycemia due to either relative lack of insulin or resistance to insulin. Diabetes is associated with a series of skeletal complications due to lowering bone mineral density and increasing the risk for bone fracture [13]. It also increases the risk for osteopenia, osteoporosis, poor osseous healing, and impaired bone regeneration [14]. Reports on diabetic animal models have suggested delayed healing of post-extraction sockets with unfavourable socket dimensions and healing response post-implantation [15-18]. However, the reports based on observation in humans (i.e., diabetic patients and/or diabetic patients on glycaemic management) indicate no deleterious effects of diabetes on post-extraction socket healing [19-21]. Furthermore, there is lack of adequate studies with detailed analysis providing an objective assessment regarding post-extraction socket dimensions over time, which would be critical for implant-based prosthetic strategies.

Few studies have reported changes in post-extraction socket dimensions in diabetic patients. However, more studies are required for a clinical community to derive effective treatment planning for implant-based prosthesis in management of single-tooth edentulous space. The objective of this study is to evaluate the change in horizontal and vertical post-extraction socket dimensions over time (healing) and the post-extraction socket morphology in diabetic patients. The study also intends to determine a favourable implant insertion time, based on the post-extraction socket dimensions in diabetic patients.

Materials and methods

Subjects and study design

The current retrospective cohort study was approved by the Ethics Committee of the Fourth Military Medical University (Ethics Approval Number: 2015 #kq-001) and was performed in accordance with the institutional ethical guidelines. Information from the records of patients who sought implant-based prosthesis following tooth extractions at the Department of Implant Dentistry, School of Stomatology, The Fourth Military Medical University in China from 2013-2015 were included in the study. Data relevant to the study were obtained only from the records of those subjects who had already provided informed consent for the use of data for research studies. The patient cohort included those with and without type 2 diabetes mellitus. Non-diabetic patients were categorized as the control group (NG; n=93) and those with type 2 diabetes formed the diabetes group (DG; n=93).

Patients' records included information such as age, gender, permanent residence (urban versus rural), smoking, other habits, occupation, systemic disease, and other relevant medical history. In addition, cone beam computed tomography (CBCT) images of both the tooth to be extracted (prior to extraction) and the post-extraction socket were essential for the current study.

Inclusion criteria: (1) For DG - confirmation of type 2 diabetes for more than three years, with a fasting blood glucose value ≥7.0 mmol/L or 2 hours plasma glucose ≥11.1 mmol/L [22] and with maximum HbA1c levels under 8.0% both before and after extraction [23]; (2) For NG - fasting blood glucose less than 7.0 mmol/L or 2 hrs plasma glucose less than 11.1 mmol/L, and maximum HbA1c levels under 6.0% before and after extraction [24]; (3) no missing teeth or bone defects on either side of the extraction site and absence of third molar if the tooth to be extracted was a second molar; (4) minimally invasive extraction or extraction with minimal trauma; (5) no record of post-operative infection; (6) pre- and post-extraction CBCT images, along with relevant medical history; (7) written informed consent.

Exclusion criteria: (1) progressive periodontitis; (2) tooth extraction due to malignancy, periodontal conditions or complex facial trauma; (3) osteoporosis and/or other metabolic or nutritional deficiencies; (4) hematopoietic, digestive or autoimmune diseases; (5) steroidal therapy; (6) smoking. Control subjects (NG) included in the study were matched to members of the DG for age, gender, tooth position, post-extraction follow-up visits, location of permanent residence, and socket dimensions. Socket dimensions included alveolar ridge width (ARW), alveolar ridge height (ARH), socket width (SW) and socket depth (SD). Similar residential location and socket dimensions, in addition to other matched variables, were chosen to reduce variation in analysis caused by these factors.

Clinical parameters

CBCT (Galileos, Sirona, Shanghai, China) images were obtained and clinical parameters analysed include socket dimensions (ARW, ARH, SW

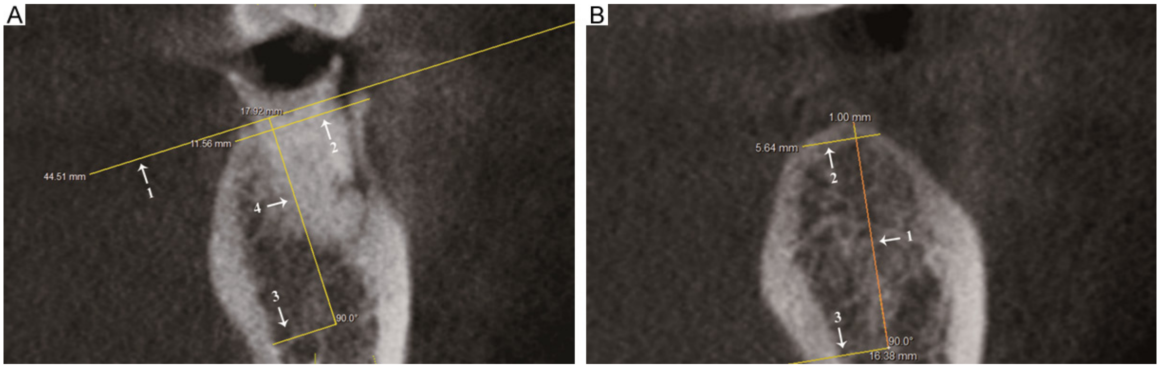

Figure 1. Measurement of the alveolar ridge width and height. A. Pre-extraction socket (tooth position 36; NG), with arrows indicating: (1) the ideal surface; (2) alveolar ridge width; (3) superior margin of the mandibular nerve canal; and (4) alveolar ridge height. B. Post-extraction socket (tooth position 36; NG), from nine months post-extraction, without well-defined post-extraction socket morphology. Arrows indicate: (1) tentative implant direction and alveolar ridge height; (2) alveolar ridge width; and (3) superior margin of the mandibular nerve canal. Image captured using GALILEOS Implant, Sirona, Shanghai, China.

and SD) and socket morphology as described eleswhwere [25]. ARW, ARH, SD, SW, and socket morphology were independently measured and analyzed with GALAXIS (Galileos, Sirona, Shanghai, China) software by two dentists who were blinded to the patients' information pre- and post-extraction. The mean values of the measurements were recorded [26]. In the event of any disagreement on the measurements, the data were then evaluated by two additional dentists. All four dentists then took additional measurements as needed, until consensus was reached.

Alveolar ridge width and height measurements

Pre-extraction: Buccolingual orientation of the CBCT images were used to measure alveolar ridge width (ARW) and alveolar ridge height (ARH). First, a reference line connecting the buccal and lingual alveolar bone peaks was drawn and termed the "ideal surface" (**Figure 1A**, arrow 1). The distance between the points connecting the outer surface of the buccal and lingual cortical plates parallel to and 1 mm below the ideal surface was considered the ARW (**Figure 1A**, arrow 2). ARH was measured perpendicular to the ideal surface (**Figure 1A**, arrows 3 and 4). In the anterior portion of the maxilla, ARH was measured as the distance from the nasal floor to the ideal surface. In the posterior portion of the maxilla, ARH was measured as the distance from the floor of the maxillary sinus to the ideal surface. In the anterior portion of the mandible, ARH was measured as the distance from the inferior margin of the mandible to the ideal surface. Whereas, in the posterior portion of the mandible, ARH was measured as the distance from the superior margin of the mandibular nerve canal to the ideal surface (**Figure 1A**, arrows 3 and 4).

Post-extraction: The socket morphology and the planned implant direction influence the measurement of post-extraction ARW and ARH. In the presence of well-defined post-extraction socket morphology, intersecting reference lines are drawn based on tentative implant direction and the ideal surface; in the absence of well-defined post-extraction socket morphology, intersecting reference lines are drawn based on the tentative implant direction (**Figure 1B**, arrow 1) and the alveolar ridge surface. The distance between the points connecting the outer surface of the buccal and lingual cortical plates parallel to and 1 mm below the ideal surface and perpendicular to the tentative implant direction/axis was considered the post-extraction ARW (**Figure 1B**, arrow 2). ARH was measured along the tentative implant direction/axis (**Figure 1B**, arrow 3). In the anterior portion of the maxilla, ARH was measured as the distance from the nasal floor to the intersection, and, in the posterior portion, it was measured as the distance from the floor of the maxillary sinus to the intersection. In the anterior portion of the mandible, ARH was measured as the distance from the inferior margin of the mandible to the intersection; in the posterior portion of the mandible, ARH was measured as the distance from the superior margin of the mandibular nerve canal to the intersection [27].

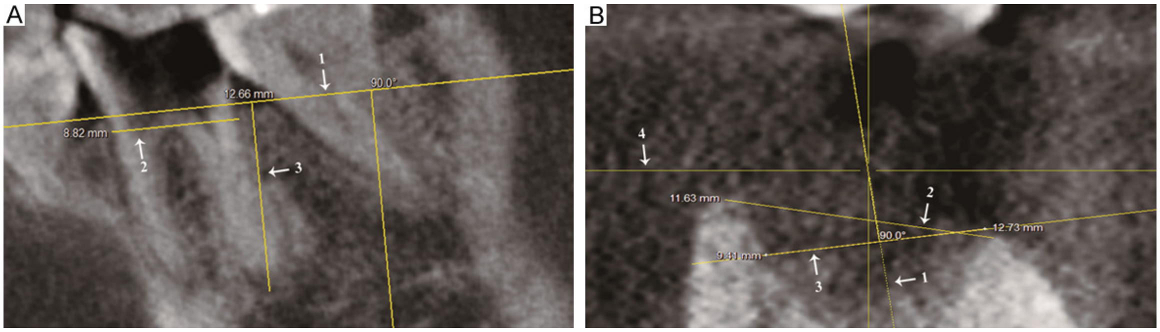

Figure 2. Measurement of the socket width and depth. A. Representative image of pre-extraction socket (tooth position 36; DG), with arrows indicating: (1) the ideal surface; (2) socket width; and (3) socket depth. B. Representative image of post-extraction socket-nine months post-extraction (tooth position 36; DG) with well-defined post-extraction socket morphology. Arrows indicate: (1) tentative implant direction; (2) ideal surface; (3) socket width; and (4) reference line. Image captured using GALILEOS Implant, Sirona, Shanghai, China.

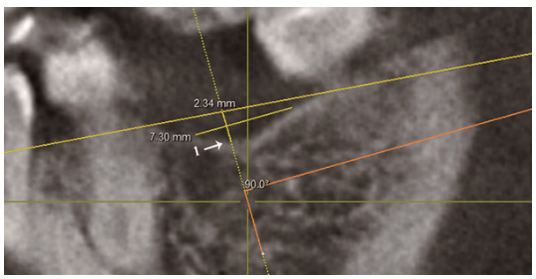

Figure 3. Measurement of the socket width and depth without well-defined post-extraction socket morphology. Arrow (1) indicates tentative implant direction and socket depth. Tooth position 36 (NG), 9 months post-extraction. Image captured using GALILEOS Implant, Sirona, Shanghai, China.

<u>*Socket width and depth measurements*</u>

Pre-extraction: Socket width (SW) and socket depth (SD) were measured in buccal-lingual and medial-distal directions. The "ideal surface" reference line was drawn as described earlier (**Figure 2A**, arrow 1), in this case between the bucco-lingual and mesio-distal bone peaks. The distance between the points connecting the inner surface of the buccal and lingual cortical plates parallel to and 1 mm below the ideal surface was considered the SW_{bl}. Similar measurements from the edges of the socket made in the mesio-distal direction were considered the SW_{md} (**Figure 2A**, arrow 2). The higher of these two measurements (SW_{bl} and SW_{md}) was considered as the SW. The measurement perpendicular to the ideal surface from the nadir point of the socket to the ideal surface was considered the SD (**Figure 2A**, arrow 3).

Post-extraction: In the presence of well-defined post-extraction socket morphology, intersecting reference lines were drawn based on tentative implant direction (**Figure 2B**, arrow 1) and the ideal surface, drawn between the buccal-lingual bone peaks (**Figure 2B**, arrow 2). In the absence of well-defined post-extraction socket morphology, intersecting reference lines were drawn based on the tentative implant direction and the ideal surface as drawn between the mesio-distal bone peaks (**Figure 1B** and arrow 3). The distance between the points connecting the buccal-lingual/mesio-distal bone peaks 1 mm below the ideal surface and perpendicular to the tentative implant direction/axis was considered the post-extraction SW (**Figure 2B**, arrow 3). SD was measured along the implant direction from the socket floor to the intersection between tentative implant direction axis and the ideal surface (**Figure 3**, arrow 1). For second molar post-extraction sockets, the ideal surface was drawn by referencing the alveolar bone of the retro-molar pad distally and the bony peak of the first molar mesially [27]. When the SD was less than 1 mm, the SW and SD were recorded as 0. Since the SD was less than 3 mm in many cases, SW was only measured at distance of 1 mm, instead of 1, 3 and 5 mm apical to the crest [2, 28].

<u>*Post-extraction follow-ups*</u>

The post-extraction socket dimension assessments were based on the follow-up schedule determined by the patients. Subsequent visits by patients were between three to 24 months. Therefore, the post-extraction socket dimen-

Table 1. Study cohort details of diabetic and non-diabetic groups

Groups (n)	Gender		Age (year)	Post-extraction follow-up (months)			
	male	female	($\chi \pm$ SD)	3	4-6	7-12	13-24
DG (93)	72	21	55.9±7.6	35	6	2	50
NG (93)	72	21	56.0±6.9	35	6	2	50
t			0.081				
p			0.372>0.05				

NG-Non-diabetic group; DG-Diabetic group; SD-standard deviation.

Table 2. Extraction and post-extraction follow-up details in diabetic and non-diabetic groups

Groups (n)	Tooth position (FDI notation)														Residence	
	Anterior teeth (18)						Posterior teeth (75)									
	11	12	21	31	41	42	16	17	26	27	36	37	46	47	Urban	Rural
DG	4	1	10	1	1	1	14	5	10	2	14	8	13	9	66	27
NG	4	1	10	1	1	1	14	5	10	2	14	8	13	9	67	26
χ^2															0.026	
P															0.871>0.05	

NG-Non-diabetic group; DG-Diabetic group.

sion evaluation was categorized into four groups: three months, -four to six months, -seven to 12 months and 13 to 24 months. The difference in post-extraction evaluation between the groups did not exceed 2 weeks.

Statistical analyses

The data were compiled using Microsoft Excel 2011, and SPSS 17.0 (SPSS Inc., Chicago, Illinois, USA) was used for statistical analyses. All the data were normally distributed. Chi-square tests and t-tests were used to determine the statistical difference between the test groups. $P < 0.05$ was considered to be statistically significant.

Results

Clinical information and CBCT images of pre- and post-extraction socket dimensions from a total of 93 subjects for each group (NG and DG) were analysed in the current retrospective study. The age in years for NG and DG were not significantly different (**Table 1**). Groups were matched for sex and residential location (**Table 1**), as well as for type/location and number of extracted teeth and post-extraction evaluation time (**Table 2**). Pre-extraction socket dimensions (SW, SD, ARW and ARH) did not differ significantly between the NG and DG (**Table 3**). However, post-extraction socket dimensions (SW and SD) were significantly different between the NG and DG (**Table 3**). Compared to the NG, the DG had higher SW and SD values in the post-extraction evaluations (at all follow-up time points; **Table 3**). In contrast, ARH values in the DG were lower in the post-extraction evaluations (at all follow-up time points) compared to the NG (**Table 3**), but the difference was not statistically significant. Similarly, no significant difference was observed in ARW in all the post-extraction evaluation time points (**Table 3**). A decrease in socket closure, as evidenced by a significantly lower difference between pre- and post-extraction SW and SD, was observed in the DG compared to the NG (**Table 4**). A significantly higher difference in post-extraction ARH was also observed in the DG compared to the NG (**Table 4**). However, the difference between pre- and post-extraction ARW was not significant between the DG and the NG (**Table 4**).

Discussion

The traditional recommendation for endosseous dental implant surgery requires that the thickness of alveolar bone be at least 5.5 mm in the buccal-lingual direction and the thickness of the buccal/labial and lingual bone be at least 1 mm to ensure both function and aesthetics [29]. Studies have reported that bone and soft tissue characteristics and success rates following immediate implant placement or delayed implant (on healed ridges) placement are similar [30-32]. However, bone resorp-

Table 3. Socket dimensions-Pre-extraction and 3-24 months post-extraction *(χ ± SD mm)*

Time (months)	Groups	Total (n)	SW	SD	ARW	ARH
Pre-extraction (3)	DG	17	8.90±1.87	7.31±0.84	9.78±1.54	13.66±3.97
	NG	17	8.04±1.40	7.38±1.12	9.44±1.55	13.98±3.99
t			1.512	-0.208	0.640	-0.234
P			0.140	0.837	0.527	0.817
Post-extraction (3)	DG	17	7.08±1.69	6.13±0.92	9.72±2.03	12.24±3.89
	NG	17	4.38±1.33	4.35±1.08	9.01±1.71	13.45±3.87
t			5.187	5.191	1.107	-0.914
P			0.000	0.000	0.276	0.367
Pre-extraction (4-6)	DG	18	7.84±1.88	7.21±1.03	9.09±2.07	13.60±4.31
	NG	18	7.62±1.65	7.36±1.00	9.19±2.20	13.13±4.15
t			0.383	-0.428	-0.143	0.332
P			0.704	0.671	0.887	0.742
Post-extraction (4-6)	DG	18	5.43±1.87	5.50±0.97	8.38±2.77	11.68±4.38
	NG	18	3.52±1.44	3.80±1.56	8.36±2.12	12.34±4.20
t			3.428	3.936	0.017	-0.457
P			0.002	0.000	0.987	0.651
Pre-extraction (7-12)	DG	8	7.24±0.41	8.24±1.77	8.85±1.58	14.52±4.58
	NG	8	7.50±0.89	7.84±1.36	8.55±1.06	14.23±4.64
t			-0.761	0.511	0.438	0.127
P			0.459	0.617	0.668	0.900
Post-extraction (7-12)	DG	8	4.17±1.91	5.33±2.71	7.25±2.20	12.27±4.62
	NG	8	2.09±0.96	2.65±1.61	7.04±1.02	13.34±4.62
t			2.751	2.403	0.247	-0.461
P			0.016	0.031	0.809	0.652
Pre-extraction (13-24)	DG	50	7.77±1.42	7.44±0.91	9.07±1.63	13.01±4.08
	NG	50	7.75±1.06	7.40±0.87	8.92±1.17	12.69±4.17
t			0.061	0.250	0.547	0.392
P			0.951	0.803	0.585	0.696
Post-extraction (13-24)	DG	50	3.53±1.97	3.63±2.01	7.34±2.19	10.51±4.20
	NG	50	0.20±0.72	0.18±0.56	7.45±1.46	11.55±4.19
t			11.216	11.688	-0.294	-1.240
P			0.000	0.000	0.770	0.218
Pre-extraction All (3-24)	DG	93	7.98±1.64	7.42±0.99	9.18±1.70	13.37±4.10
	NG	93	7.76±1.24	7.42±0.98	9.03±1.48	13.14±4.15
t			1.041	-0.065	0.646	0.383
P			0.299	0.949	0.519	0.703
Post-extraction All (3-24)	DG	93	4.65±2.35	4.60±2.04	7.97±2.43	11.21±4.22
	NG	93	1.85±2.14	1.93±2.17	7.88±1.73	12.20±4.18
t			8.476	8.610	0.298	-1.623
P			0.000	0.000	0.766	0.106

NG - Non-diabetic group; DG - Diabetic group; Socket width (SW); Socket depth (SD); Alveolar ridge width (ARW); Alveolar ridge height (ARH).

tion was observed both at control and implant sites, especially on the buccal socket [33]. Hence, buccal bone thickness and horizontal socket dimensions should be considered dur-

Table 4. Mean difference in post-extraction socket dimensions *(χ ± SD mm) (rate of change)*

Time (months)	Groups	Total (n)	SW	SD	ARW	ARH
(3)	DG	17	↓1.81±0.65 (20.3%)	↓1.18±0.50 (16.1%)	↓0.06±0.75 (0.6%)	↓1.42±0.70 (10.4%)
	NG	17	↓3.66±0.55 (45.5%)	↓3.04±0.77 (41.2%)	↓0.43±0.60 (4.6%)	↓0.53±0.28 (3.8%)
t			-8.941	-8.331	-1.600	4.913
P			0.000	0.000	0.120	0.000
(4-6)	DG	18	↓2.41±0.72 (30.7%)	↓1.72±0.99 (23.9%)	↓0.71±1.05 (7.8%)	↓1.92±0.67 (14.1%)
	NG	18	↓4.10±1.09 (53.8%)	↓3.56±1.06 (48.4%)	↓0.83±0.45 (9.0%)	↓0.79±0.28 (6.0%)
t			-6.432	-5.525	-1.033	6.081
P			0.000	0.000	0.309	0.000
(7-12)	DG	8	↓3.07±1.68 (42.4%)	↓2.91±1.74 (35.3%)	↓1.59±1.15 (18.0%)	↓2.25±0.71 (15.5%)
	NG	8	↓5.42±1.04 (72.3%)	↓5.19±1.77 (66.2%)	↓1.51±0.87 (17.7%)	↓0.89±0.28 (6.3%)
t			-3.366	-2.592	0.162	5.066
P			0.005	0.021	0.873	0.000
(13-24)	DG	50	↓4.24±1.53 (54.6%)	↓3.81±1.97 (51.2%)	↓1.73±1.19 (19.1%)	↓2.50±0.63 (19.2%)
	NG	50	↓7.55±1.23 (97.4%)	↓7.21±1.14 (97.4%)	↓1.47±0.71 (16.5%)	↓1.14±0.41 (9.0%)
t			-11.946	-10.583	1.354	12.895
P			0.000	0.000	0.179	0.000
All (3-24)	DG	93	↓3.34±1.63 (41.9%)	↓2.85±1.95 (38.4%)	↓1.22±1.27 (13.3%)	↓2.17±0.77 (16.2%)
	NG	93	↓5.99±2.05 (77.2%)	↓5.57±2.17 (75.1%)	↓1.16±0.78 (12.8%)	↓0.94±0.42 (7.2%)
t			-9.729	-9.017	0.380	13.531
P			0.000	0.000	0.704	0.000

NG - Non-diabetic group; DG - Diabetic group; Socket width (SW); Socket depth (SD); Alveolar ridge width (ARW); Alveolar ridge height (ARH).

ing implant placement [34]. The alveolar ridge undergoes horizontal and vertical reduction by 3.8 mm and 1.24 mm respectively, six months post-extraction [4]. In humans, horizontal bone dimension was reduced by 29-63% and vertical by 11-22%, six months post-extraction, and the observed decrease was rapid during the first three to six months post-extraction [3]. The vertical and horizontal bone dimensions at the implant site decreased by 0.5-1.0 mm during 4-12 months follow-up after immediate implant insertion [35]. In this study, the mean SW at three months post-extraction in the DG was 7.08±1.69 mm and 4.38±1.33 in the NG. The results suggest that the SW poses no risk to implant surgery in patients with healthy blood glucose levels, because there are implants with sufficiently large diameters from which to choose. However, for diabetic patients, it is difficult to find an appropriate implant. If an implant of 4.5 mm diameter is normally chosen for such patients, there would be a mean of 2.5 mm of empty space around the implant neck that would need to be filled or left empty. Although the empty space may not affect primary implant stability, it also may affect osseointegration around the implant neck, which can cause bone resorption and aesthetic risk [36]. Thus, healing time must be extended to achieve ideal socket healing for diabetic patients. Guided bone regeneration technique could be used to fill the empty space around the implant neck, which could cause marginal bone loss. Meanwhile, if implantation is not delayed to allow for slower healing in diabetic patients, difficulties in finding appropriate implants and positioning can also lead to aesthetic compromises [6, 37].

Compared to healthy people, diabetic patients have a higher probability of periodontitis and of alveolar bone loss secondary to tooth loss [38]. *In vivo* studies have reported unfavourable socket healing and alveolar bone destruction in diabetic animals [15-18]. Expression of TGF-beta isoforms and TGF-beta receptor genes, essential for wound healing, were significantly downregulated in the diabetic animals following tooth extraction [39, 40]. Decreased differentiation of osteoblasts and mineral apposition rates were observed in diabetic animals, contributing to delayed healing [18, 41]. Insulin-like growth factor I (IGF-I) increases the differentiation of osteoblasts and mineralization of bone. Thus, treatment with IGF-1 improved alveolar bone morphology in diabetic rats exhibiting decreased alveolar bone formation [15]. Similarly, metformin administration or Ellagic acid combined with statins improved post-extraction socket healing in rats [17, 42]. Mineral apposition rate following immediate implant insertion was significantly decreased in the diabetic rats compared to the normal rats [41]. However, in humans, there have been favourable reports on post-extraction socket healing and implant outcomes in diabetic patients, especially in those with controlled hyperglycaemia [19-21, 43, 44]. Furthermore, improved post-extraction healing characteristics were observed with the use of plasma-rich growth factor (PRGF) in sockets of diabetic patients [45]. Bone quality has significant positive correlations with HbA1c level [46]. The results in our study were obtained from diabetic patients with good blood glucose control. However, in patients without good glycemic control, dental implant therapy must accommodate for delays to ensure adequate osseointegration [47].

However, the SD and SW were statistically different between the DG and the NG as early as 3 months post extraction ($P < 0.05$). The mean socket width 4-6 months post extraction of diabetic group was 5.43±1.87 mm and 3.52±1.44 mm of non-diabetic group. Four to six months post-extraction is thus the best time to insert implants for diabetics. The ARH 4-6 months post-extraction reduced 1.92 mm, indicating that a longer healing period may increase aesthetic risk. Therefore, we suggest intervention, such as alveolar ridge preservation techniques (e.g., guided bone regeneration), early on. Depending on pre-extraction bone loss, bone augmentation can be carried out [48, 49]. Many clinical trials confirm that alveolar ridge preservation techniques can reduce the height and width of reduction at extraction sites [27, 50, 51]. These techniques can reduce aesthetic risk and achieve required bone density for implant insertion [52]. Since all existing studies have focused on non-diabetic patients, the implications for diabetic patients are rather unclear.

Based on this study and others, we have the following recommendations for diabetic patients: early intervention, minimally invasive extraction, good blood glucose control, smoking cessation, and a 4-6 month delay in implant insertion [53]. Whether alveolar ridge preservation techniques could be used in diabetics remains unknown, and delay of prosthesis will increase the risk of unfavourable aesthetics and a prolonged treatment period [54]. To optimize treatment strategies, reduce treatment time, and improve treatment outcome, the relevance of routine alveolar ridge preservation techniques in diabetics needs further study.

Acknowledgements

The authors acknowledge and thank the National Natural Science Foundation of China for funding this study (No. 81170984; 81470775). The authors also thank Dr. Wei Ma, Dr. Chao Xie and Dr. Yan Liu, for their assistance with statistics and language.

Disclosure of conflict of interest

None.

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