# A Systematic Review of the Effectiveness of Bone Collectors

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***Purpose:*** *Bone collectors are used to harvest bone debris for grafting procedures during implant surgery. The particulate bone debris gathered through filtration has been frequently used in minor regenerative surgical procedures. Nevertheless, the biological potency of such grafts is still unclear. The objective of this study was to systematically review the use of bone collectors in implant dentistry, focusing on the quantity, quality, and bacterial contamination of the bone collected.* ***Materials and Methods:*** *Following the production of a detailed protocol, screening and quality assessment of the literature were conducted in duplicate and independently. The outcome measures that were assessed were:* (1) *quantity of collected debris,* (2) *quality of the collected bone debris, and* (3) *bacterial contamination.* ***Results:*** *There is a limited amount of information on the nature of bone obtained through collectors. Eleven studies satisfied the inclusion criteria. Bone collectors are able to retain a small amount of bone for minor surgical procedures. The presence of vital bone cells has not been demonstrated routinely, while consistent bacterial contamination has been observed.* ***Discussion:*** *Bone collected through bone filters appears to be sufficient for small regenerative procedures. Clinicians should bear in mind that presence of bacterial pathogens is always shown with the use of bone collectors. Presurgical chlorhexidine oral rinsing and a strict aspiration protocol must be used to minimize the bacterial contamination of the debris collected.* ***Conclusions:*** *Although bone collectors are capable of amassing small amounts of bone, the vitality of this bone could not be consistently demonstrated and the collected debris was always contaminated by bacteria. Therefore, the bone debris amassed in bone collectors is not an ideal grafting material and should be utilized with caution.* Int J Oral Maxillofac Implants 2007;22:729–735

**Key words:** *bone collectors, bone traps, dental implants, oral surgery, systematic review*

Autogenous bone is considered the gold standard for grafting materials because of its superior osteogenic and osteoinductive properties.[1–4] The choice of an autogenous donor site is often based on the amount of bone needed. Extraoral bone grafts are usually taken from the iliac crest,[5–7] the tibia,[8] or the skull[5] and are used when large amounts of bone are needed.[9,10] These procedures result in significant morbidity and discomfort for the patient.[6,11] Conversely, when smaller amounts of bone are required, intraoral grafting sources are usually preferred to decrease patient discomfort postoperatively.[12] The use of intraoral sources for grafting has several advantages, including reduced operating time, lower morbidity, reduced hospitalization time, and avoidance of cutaneous scarring.[2,12,13] A second surgical site is still needed. However, the need for a second surgical site can be avoided with the use of bone collectors to obtain bone during the surgical procedure.

Bone collectors, or bone traps, are filters placed in the surgical suction device to collect the bone debris produced during bone drilling for implant site preparation (Fig 1). These devices were first described in the periodontology literature[14,15] and subsequently reported in the otolaryngology literature.[16,17] More recently, collected bone debris has also been used for bone augmentation to correct small peri-implant

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**Fig 1** Debris collected with a bone filter.

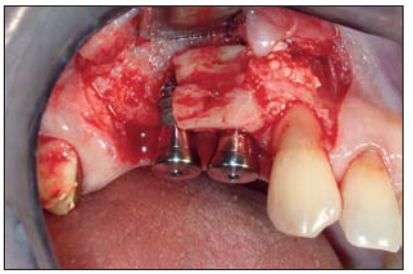

**Fig 2** Dehiscence-like bony defect.

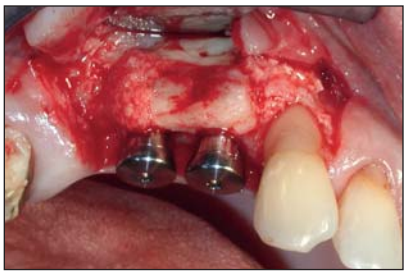

**Fig 3** Filtered material grafted in the peri-implant defect.

defects (Figs 2 and 3).[18,19] The use of bone collectors allows acquisition of bone for grafting with no additional discomfort for the patient.[20] However, little evidence exists to provide guidelines for the use of bone collectors in implant dentistry, as few studies have assessed the material that is amassed in these devices.[21–24] Particularly, the ability to retain bone, the quality of the collected debris, and the possibility of bacterial contamination are of critical importance. The rationale of autogenous bone grafts is based on the assumption that sufficient bone debris would be collected and that such debris retains its osteogenic potential and is free of bacterial infection.[4] However, it is not clear whether these properties are preserved following the milling and filtration process.

The aim of this study was to evaluate, through a systematic review of the literature, the biologic rationale supporting the clinical usage of bone collectors in implant dentistry.

## MATERIALS AND METHODS

### Study Selection

To be eligible for inclusion in the review, studies had to examine bone debris collected with the use of bone collectors in in vivo models. No language restrictions were applied.

The outcome measures that were assessed were

- ability to retain bone debris
- quality of the collected debris
- bacterial contamination of bone debris collected

### Searching

Searches of the Central Register of Controlled Trials (CENTRAL), PUBMED, and EMBASE were conducted through January 2006 using the search strategy: 'bone trap$' OR 'bone collect$'. All the titles and abstracts were analyzed by 2 reviewers (FG, FLF). Hand searching included *International Journal of Oral & Maxillofacial Implants, Clinical Oral and Implants Research, Journal of Oral and Maxillofacial Surgery, International Journal of Oral and Maxillofacial Surgery,* and *British Journal of Oral and Maxillofacial Surgery.* The reference lists of the included articles were reviewed for the presence of other eligible publications. Articles included were later analyzed *in extenso.*

### Validity Assessment of Review Method

The reviewers were calibrated for study screening against the lead reviewer (FG). Each round of calibration consisted of a duplicate, independent validity assessment of 20 titles and abstracts from the search. After 2 rounds of calibration, a consistent level of agreement was found (unweighted K score from first to third exercise: 0.9, 1, 1). Only studies on the use of bone collectors describing at least 1 of the 3 outcome measures were included in the review. Any disagreement was resolved by discussion among reviewers (FG, FLF, MG).

### Data Synthesis

Data were synthesized in evidence tables using mean and range. Decisions on possible meta-analysis were made based on the similarity between the studies.

## RESULTS

The electronic search identified 98 articles (Fig 4). Screening of titles and abstracts led to rejection of 90 articles. The full text of the remaining 8 articles was then obtained (Table 1). Hand searching identified an additional 7 articles for full-text analysis. Four of these articles were later excluded. Therefore, 11 articles met the criteria for inclusion in this systematic review (Table 2). No meta-analysis was performed due to the heterogeneity of the included studies, especially in terms of the use of different bone collectors and a variety of clinical methodologies.

### Characteristics of the Bone Collectors in the Included Studies

Five different types of bone collectors were described in the included literature. These 5 devices

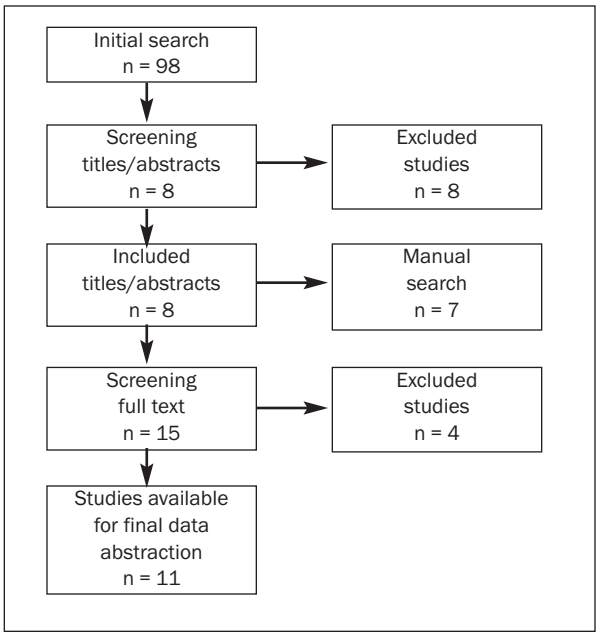


**Table 1 Reasons for Exclusion of Studies**

| | No. of studies |
|---|---|
| No. of articles excluded on the basis of their abstracts | 90 |
| Humans studies: no usage of bone collectors | 41 |
| Animals studies: no usage of bone collectors | 49 |
| Excluded full-text articles | 4 |
| Clinical studies not assessing inclusion criteria | 2 |
| Bone not collected in vivo | 2 |

**Fig 4** Flow of articles during the review.

are commercially available: Osseous Coagulum Trap (OTC Quality Aspirators; Duncanville, TX); Frios bone collector (FBC; Friatec, Mannheim, Germany); IMTEC bone collectors (IM; IMTEC, Ardmore, OK), Knochenfiters KFT2 (KF; Schlumbohm OHG, Brokstedt, Germany), and Fa (FA; Sulzer-Medica, Freiburg, Germany).

### Ability to Retain Bone Debris

Two studies investigated the clinical performance of the bone traps with regard to the amount of bone collected.[20,24] A mean of 0.03 g of bone (range: 0.02 to 0.09 g) was obtained during single implant site preparation with OTC; a mean of 0.05 g (range: 0.00 to 0.08 g) was obtained with FBC.[24] During multiple maxillary implant site drilling, the amount of bone collected was 0.34 g (range: 0.07 to 0.06 g) with OTC and 0.09 g (range: 0.01 to 0.18 g) with FBC. Significant differences were only observed between OTC and FBC with respect to the amount of bone collected following multiple mandibular implant site preparation: 0.14 g (0.07 to 0.28 g) using OTC compared to 0.06 g (0.02 to 0.14 g) using FBC.[24]

Volumetric measurements were performed in only 1 study. Twenty-four implants (4.0 × 13 mm implants) were placed in 9 patients. Bone collectors (IM) were used in each implant surgery. A mean of 0.163 ± 0.070 mL of bone was collected in the mandible, while a mean of 0.196 ± 0.099 mL was collected in the maxilla.[20] No statistical differences were reported between the maxilla and mandible or with respect to patient age or sex.

### Quality of the Collected Debris

Six studies considered the quality of the collected debris utilizing a variety of techniques aimed at assessing its vitality and osteogenic potential.[1,4,20,21,24,25]

Histologic analysis of the debris collected during implant surgery indicated that the material was composed of bone and coagulum.[24] The collected bone showed a well-preserved structure with a large amount of osteocytes in a calcified matrix.[21] The results were not stratified according to the type of device used.

Histomorphometrically, the percentage of bone in the samples collected by FBC ranged from 92% to 100%, whereas in the samples collected by OCT, the percentage of bone ranged from 0% to 85%. Excess coagulum was noticed every time a blockage occurred during surgery (11 times for OCT and 1 time for FBC).[24]

Osteoblast-like cells could be identified in only a portion of the collected samples. Using the FA bone collector, the presence of bone cells was detected in 65% of the total trapped material from human implant sites.[25] In an animal porcine model, cellularity was noticed in only 5 of 10 explants; FBC was used.[1]

Using cortical bone material harvested from pigs, cell outgrowth was 487 ± 413 cells/mg after 14 days.[1] The number of cells seemed to be affected by the type of bur used during drilling; more cells were maintained with the use of diamond ball drills compared to implant burs and ball reamers.[4]

A comparison of the bone material obtained using bone filters with that obtained through chisels or

**Table 2 Characteristics of the Included Studies**

| Study | Type of studies | No. of subjects in test group | Procedure | Collection areas | Bone collector used | Aspiration protocol | Ability to retain bone debris | Quality of the collected debris | Bacterial contamination of bone debris collected |
|---|---|---|---|---|---|---|---|---|---|
| Blay et al (2003) | Clinical trial | 30 | Implant surgery | Not specified | OCT; FBC | Restrict aspiration protocol | Not estimated | Bone structure preserved; collected debris contained large number of osteocytes within the calcified matrix | Qualitative microbiological evaluation showed the presence of normal microbiologic environment of the oral and oral-pharyngeal cavity |
| Glaser et al (2004) | Clinical trial | 50 | Drilling | Not specified | KF | Restrict aspiration protocol | Not examined | Not examined | Aerobic (435,000 CFU) and anaerobic (1,013,000 CFU) |
| Gruber et al (2005) | In vitro study | 2 | Drilling | Maxilla and mandible | FBC | Not specified | Not examined | After 2 weeks of culture, 487± 413 cells/mg of bone dust | Not examined |
| Kuttenberger et al (2005) | Clinical trial | 39 | Implant surgery | Not specified | OCT | Restrict aspiration protocol | Not examined | Not examined | Microbial contamination of 82.7% of samples without chlorhexidine rinse; microbial contamination of 33.3% of microbial contamination with chlorhexidine rinse |
| Kürkçü et al (2005) | In vitro study | 25 | Drilling | Mandible | FBC | Restrict aspiration protocol | Not examined | Not examined | Test group (chlorhexidine rinse): $1.5 \times 10^8$ CFU/g; control group, $1.5 \times 10^9$ CFU/g |
| Pradel et al (2005) | In vitro study | 20 | Drilling | Maxilla and mandible | FA | Restrict aspiration protocol | Not examined | Cell growth in 65% of bone-sludge cultures. Cells able to proliferate and differentiate in subculture | Not examined |
| Young et al (2001) | Clinical trial | 24 | Implant surgery | Not specified | FBC | Stringent aspiration protocol/Non-stringent aspiration protocol | Not examined | Not examined | S: $4071 \times 10^5$ CFU<br>NS: $9634 \times 10^5$ CFU |
| oung et al (2002) | Clinical trial | 20 | Implant surgery | Not specified | FBC | Restrict aspiration protocol | Not examined | Not examined | Test group (chlorhexidine rinse): $0.72 \times 10^5$ CFU; control group: $3.43 \times 10^5$ CFU |
| Young et al (2002) | Clinical trial | 38 | Implant surgery | Maxilla and mandible | OCT; FBC | Restrict aspiration protocol | Single-tooth maxillary implant (0.031 g OCT; 0.054 g FBC); multiple maxillary implants (0.34 g OCT; 0.088 g FBC); multiple mandibular implants (0.14 g OCT, 0.061 g FBC) | FBC: samples were 92% to 100% bone; OCT: samples were 0% to 85% bone | Not examined |
| Savant et al (2001) | Clinical trial | 9 | Implant surgery | Maxilla and mandible | IM | Restrict aspiration protocol | 0.195 mL of bone obtained from a site 4.0 × 13 mm | Not examined | Not examined |
| Springer et al (2004) | In vitro study | 48 (all study)<br>24 (bone traps) | Drilling with:<br>A: diamond ball drill<br>B: implant drill<br>C: ball reamer | Mandible or iliac crest | Not specified | Not specified | Not examined | Cell count gained from 0.5 mg from each sample after 4 weeks of culture: A: 428,990; B: 150,000; C: 91,400. Milling process reduced the quantity of osteoblasts | Not examined |

OTC = Osseous Coagulum Trap (Quality Aspirators; Duncanville, TX); FBC = Frios bone collector (Friatec, Mannheim, Germany); KF = Knochenfilters KFT2 (Schlumbohm OHG, Brokstedt, Germany); IM = IMTEC bone collector (Ardmore, OK); Fa = FA (Sulzer-Medica, Freiburg, Germany).

curettes showed a higher cell viability for the latter. Cell growth approximately doubled when cells were obtained through curettage compared to filtering when the source was spongy bone.[4] This difference was less evident when cortical bone was collected by the 2 methods.[4] Furthermore, osteoblast-like cells derived from filtered material showed a lower capacity to proliferate than cells from chiseled bone, with 18 days needed to observe cell outgrowth compared to 8 in the chiseled-bone group.[25]

Cell differentiation assays indicated that osteoblast-like cells obtained with bone collectors were able to produce alkaline phosphatase,[1,4,25] osteocalcin,[4,25] and collagen I.[25] No significant differences were reported between these cells and cells obtained through curettage or chiseling in terms of cell differentiation.[1,4,25]

### Bacterial Contamination of the Bone Debris Collected

Bacterial contamination of bone debris collected was analyzed in 6 studies.[21–23,26–28] Bacterial contamination was consistently noted.

Quantitative analysis showed basal bacterial contamination of collected bone debris of $9.63 \times 10^5$ colony-forming units (CFU).[22] Qualitatively, potentially pathological bacterial species were identified. Specific aerobic species included *Enterococcus faecalis, Staphylococcus epidermidis,*[22,23] *Staphylococcus aureus,*[21,23,28] *Streptococcus* $\alpha$*-hemolyticus,* and *Streptococcus* $\beta$*-hemolyticus.*[21,28] Within the anaerobic group, *Actinomyces odontolyticus,*[22,23,26,28] *Prevotella intermedia,*[21–23,26] *Propionibacterium propionicum, Peptostreptococcus asaccharolyticus,*[22,23] *Peptostreptococcus micros,* and *Eubacterium* species,[22] were observed.

Contamination was shown to be significantly reduced by judicious precautions. The use of a restricted aspiration protocol, which involved a dedicated salivary suction device, achieved a reduction in bacterial count of 58% (from $9.63 \times 10^5$ to $4.07 \times 10^5$ CFU).[24]

The overall bacterial load can also be reduced with a 2-minute rinse of 0.2% chlorhexidine preoperatively. Using different experimental protocols, observed bacterial load decreases ranged from 3-fold (from $3.43 \times 10^5$ CFU to $0.72 \times 10^5$ CFU)[23] to 10-fold (from $1.5 \times 10^9$ CFU/g to $1.5 \times 10^8$ CFU/g).[27] Significantly, the anaerobic counts decreased from $2.34 \times 10^7$ to $1.02 \times 10^5$.[27] A preoperative chlorhexidine rinse eliminated pathogens such as *A odontolyticus, P intermedia, E faecalis,* and *Clostridium bifermentans,* whereas contradictory results were reported for *Fusobacterium* species.[23,27]

Rinsing the bone particulate with 200 mL of a 0.1% chlorhexidine solution significantly reduced microbial contamination. When the collector was not rinsed with chlorhexidine, microbial contamination was found in 82.7% of the samples, and 37 different microbial species were identified in culture. However, when the collector was rinsed with chlorhexidine, only 33.3% of the samples were contaminated, and only 11 species were found, mostly streptococci.[28]

## DISCUSSION

This systematic review assessed the material amassed in bone collectors in terms of quantity, quality, and bacterial contamination. Although bone collectors were capable of acquiring bone, the quality of the collected bone was variable, and consistent bacterial contamination was detected.

Bone collectors are designed to gather the relatively small amounts of bone produced during implant site preparation.[20,24] Clinically, the amount of bone material collected appears to be sufficient to cover small peri-implant bone defects such as fenestrations and dehiscences. However, the small amount of particulate bone that is obtained often necessitates the use of the collected debris in combination with xenografts or alloplastic materials to provide sufficient material to fill defects. This undermines the economical advantage of bone collectors. Not surprisingly, bone quantity increases when multiple implant site are prepared.[20,24] The quantity of collected bone seems to depend neither on the site of implant placement (mandible versus maxilla) nor on the age or gender of the patient.[20]

The amount of collected bone may be influenced by the net filter mesh diameter.[29,30] Since filter blockage could occur because of excess coagulum, bone collectors cannot be accurately assessed by nonclinical studies. Indeed, pore size affected both the clinical performance and histological composition of the debris collected, because bigger pore size retained larger bone particles and avoided the accumulation of excess coagulum. Indeed, different bone collectors produce different amounts of bone. Smaller-diameter meshes yielded a larger proportion of coagulum within in the collected material and often became blocked.[24]

Ideally, a grafting material should not only be sufficient in terms of quantity but should also contain vital bone-forming cells. It is important to determine whether this property is compromised by the aspiration process. When bone particulate vitality was analyzed, osteoblast-like cells were shown to express alkaline phosphatase and osteocalcin, which are markers of osteogenic cell differentiation.[1,4] Data from these studies confirmed the presence of osteoblast-

like cells which could proliferate and differentiate along the osteogenic lineage, suggesting that they are capable of contributing to bone regeneration following transplantation. However, cell outgrowth was observed in only approximately half of all collected bone samples.[1,25] This can be explained by the small number of cells present in cortical bone or by the damage inflicted to the cells during the drilling and aspiration process. Indeed, in vitro studies have shown that bone milling can reduce the quantity of osteoblasts; in one study, the debris obtained from the drill following the use of hard alloy ball reamers resulted in the least amount of viable cells compared to unmilled bone.[4] In addition, frequently found bacterial contamination may decrease the amount of cellular outgrowth from the collected material.[25]

Histologic assessment of the osteogenic and osteoinductive capacity of the collected bone is fundamental in determining the clinical value of utilizing bone traps. Only 1 clinical study has reported the presence of new bone matrix at the grafted site after 6 to 8 months.[21] However, bearing in mind that the collected bone debris frequently contains no viable bone cells, this result, interpreted by the authors as demonstrating the osteogenic potential of the original bone graft, could also be explained by the osteoconducive properties of a nonvital graft, which could act as a scaffold and maintain space for subsequent fill by viable surrounding bone cells.

Bacterial contamination of the graft is an important factor in determining graft and implant survival.[25,31–36] Collected bone debris contained significant levels of bacteria, and this represents a significant disadvantage in using bone collectors.[21–23,26,27] Microbial analysis identified a large number of common saprophytes, including different species associated with a wide range of infections.

A stringent aspiration protocol, combined with the adjunctive use of a preoperative chlorhexidine oral rinse, can considerably reduce the contamination levels in the collected debris.[22–24,26,28] Rinsing the bone particulate with chlorhexidine solution can also significantly decrease microbial contamination, but no data are available on the effects of this type of rinsing on cell vitality.[28] Nevertheless, bacterial contamination remains a significant limitation which has not yet been fully overcome. Therefore, measures should be taken to disrupt the biofilm preoperatively, and a stringent aspiration protocol is recommended when bone debris is collected in the oral cavity.[22] In the context of minimizing bacterial contamination, a possible alternative to bone collectors is the use of bone scrapers,[37,38] which allow clinicians to collect autologous bone shavings from the cortical surface in the vicinity of the surgical site.

In conclusion, the available evidence suggests that the use of bone collectors can yield grafting material which can be used to augment small periimplant defects. However, despite various disinfection protocols, bone obtained through filtering always shows the presence of pathologic bacterial species. In addition, the presence of vital bone-forming cells is not a consistent finding in collected bone. Therefore, the limited available evidence regarding the use of bone collectors suggests that the resultant grafting material is less than ideal. Unless different methods to avoid bacterial contamination or different device designs are developed, clinicians should be cautious in the use of bone collectors.

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